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**HIGH ENERGY PHYSICS DIVISION
SEMIANNUAL REPORT OF
RESEARCH ACTIVITIES**

July 1, 1999 - December 31, 1999

Prepared from information gathered and edited by
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June 2000

Abstract

This report describes the research conducted in the High Energy Physics Division of Argonne National Laboratory during the period of July 1, 1999 through December 31, 1999. Topics covered here include experimental and theoretical particle physics, advanced accelerator physics, detector development, and experimental facilities research. Lists of Division publications and colloquia are included.

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I. EXPERIMENTAL RESEARCH PROGRAM

I.A. EXPERIMENTS WITH DATA

I.A.1 Medium Energy Physics Program

In the latter half of 1999, accomplishments for the ANL-HEP division medium energy physics project consisted of the publication of four papers on past Saclay experiments, and the continuation on analysis of recent data from the Crystal Ball measurements at the Brookhaven AGS.

Two Saclay papers were published about pp elastic and quasi-elastic, and pn quasi-elastic scattering by a polarized proton beam on a polarized ${}^6\text{LiH}$ and ${}^6\text{LiD}$ target (J. Ball, *et al.*, Eur. Phys. J. **C11**, 51 and 69 (1999)). The other two papers were written by an ANL physicist about measurements of pp elastic scattering analyzing powers at beam kinetic energies between 800 and 2800 MeV and c.m. angles from about 70° - 110° based on data analysis at Saclay and Argonne (C. Allgower, *et al.*, Phys. Rev. **C60**, 054001 and 054002 (1999)). Work has also begun on two additional papers at Argonne.

Measurements of reactions with π^- , K^- , and \bar{p} beams on a liquid hydrogen target to all neutral final states were made with the Crystal Ball detector at the Brookhaven AGS in late 1998. Analysis has continued at Argonne and Valparaiso University on some of the kaon and antiproton beam data. In addition, a paper was submitted for publication ("Search for the CP-Forbidden Decay $\eta \rightarrow 4\pi^0$ " by S. Prakhov, *et al.*) to Phys. Rev. Lett. on some of the Crystal Ball data.

One ANL task involved analysis of the few hours of $\bar{p}p \rightarrow \text{neutrals}$ data collected. A cut was applied to require that essentially all of the initial state energy be deposited in the Crystal Ball. This requirement yielded a set of about 300 events which were studied event by event using a special display program and calculations of invariant masses of sets of detected energy clusters. Many different reaction channels were observed, most with only one or a few unambiguous events. The derived cross section for $\bar{p}p \rightarrow 3\pi^0$ at 550 MeV/c was found to agree well with previous measurements. A note describing this analysis was written to document the channels observed, the estimated event rates, and problems encountered in case a proposal is written in the future to study these antiproton reactions.

A second analysis topic involved study of the $K^-p \rightarrow \Sigma^0 \pi^0 \rightarrow (\gamma\eta\pi^0)\pi^0$ reaction. A number of cuts have been applied to insure that the invariant masses of appropriate pairs of γ 's correspond to M_{π^0} and the missing mass of the production π^0 is approximately the Σ^0 mass, etc. Differential cross sections were derived using calculated acceptances, the

measured beam intensity and target length. Preliminary results for a fraction of the data collected at 750 MeV/c are shown in Figure 1 and compared to earlier bubble chamber results (R. Armenteros, *et al.*, Nucl. Phys. **B21**, 15 (1970)). The agreement is quite good, though additional corrections still need to be applied.

The third analysis task was the addition of more counters, materials, shielding, collimators, etc. to the Crystal Ball Monte Carlo program. These additions are being tested and some results have already been derived. Problems were found with simulations of low energy neutron interactions using the FLUKA (and GHEISHA) hadronic code in GEANT. This information was of importance to a paper being written on detection of neutrons in the Crystal Ball. It is hoped to have the Monte Carlo additions completed and documented by spring, 2000.

Finally, discussions with program officers at DOE-NP have begun to supplement the funding of this program to include studies of the proton spin at RHIC, and construction of the shower maximum detector for the STAR endcap electromagnetic calorimeter.

(H.M. Spinka)

**VERY Preliminary Cross Sec (20% of Data)
750 MeV/c (Runs 654,6,7,8) Lev4 & Edge Cuts**

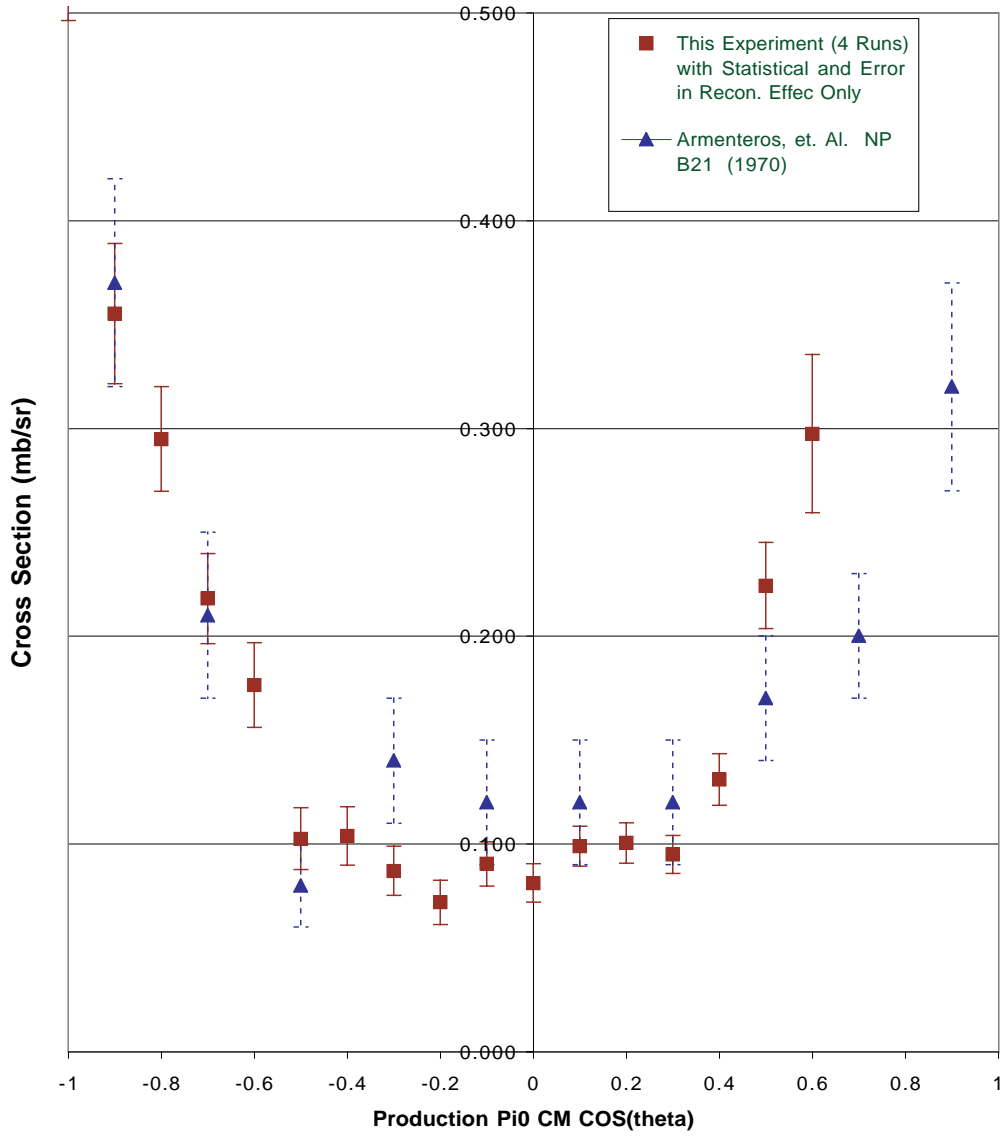


Figure 1. Preliminary differential cross-section for the reaction $K^- p \rightarrow \Sigma^0 \pi^0$ at 750 MeV/c kaon beam momentum from the Crystal Ball detector at the AGS. Also shown are earlier results from a bubble chamber experiment.

I.A.2 Collider Detector at Fermilab

a. Physics Results

In B physics, the multiple tag CP analysis of $B^0/\bar{B}^0 \rightarrow \Psi K_s^0$, with Barry Wicklund providing oversight as B physics convener and Larry Nodulman as chief internal reviewer, which measures the CP violation parameter $\sin(2\beta) = 0.79_{-0.44}^{+0.41}$, was written up in an article which went through collaboration approval and was submitted for publication. Other B physics results becoming public included B^0 oscillation measurements and production characteristics of heavy flavor bound states, ψ and χ . The Toronto group in b jet fragmentation results, which included efficiencies determined by Karen Byrum, was published. Barry Wicklund has been extended for another year as B physics co-convener.

In electroweak physics, a comprehensive W mass analysis was put together and made public for the winter conferences. The result, using an energy scale from the Z mass for both electrons and muons, due to unresolved mysteries in tracking, is being written up in a long article, with Larry Nodulman contributing text. The electron and muon result for the 94-95 data is 80.470 ± 0.089 which combined with earlier CDF measurements gives 80.443 ± 0.079 GeV/c². The current world average is 80.419 ± 0.038 GeV/c². Tom LeCompte and Larry Nodulman served as internal reviewers of a study of high mass Drell-Yan production by members of the Rochester group which was submitted for publication. Adam Hardman's work on the W width from the muon sample was combined with the electron result and is going through the collaboration approval process to be submitted.

In QCD studies, Steve Kuhlmann, working with the Brandeis group, is extending the study of direct photon production in the 94-95 data to the $\sqrt{s} = 630$ GeV data. The preliminary results are shown in Figure 1. Jet algorithm optimization studies are continuing. Bob Blair has become co-convener of QCD physics.

b. Run II Planning

A series of Run II physics workshops continues at Fermilab. Steve Kuhlmann has taken a leading role in QCD issues and optimizing two b jet mass resolution for Higgs searches. Larry Nodulman has been involved in electroweak sessions, on W mass issues. A new workshop on Tevatron Collider b physics for CDF, D0, and BTeV has begun and Barry Wicklund is one of the principal organizers. Barry also continues to take an important role within CDF in defining planned triggers and datasets for b physics.

(L. Nodulman)

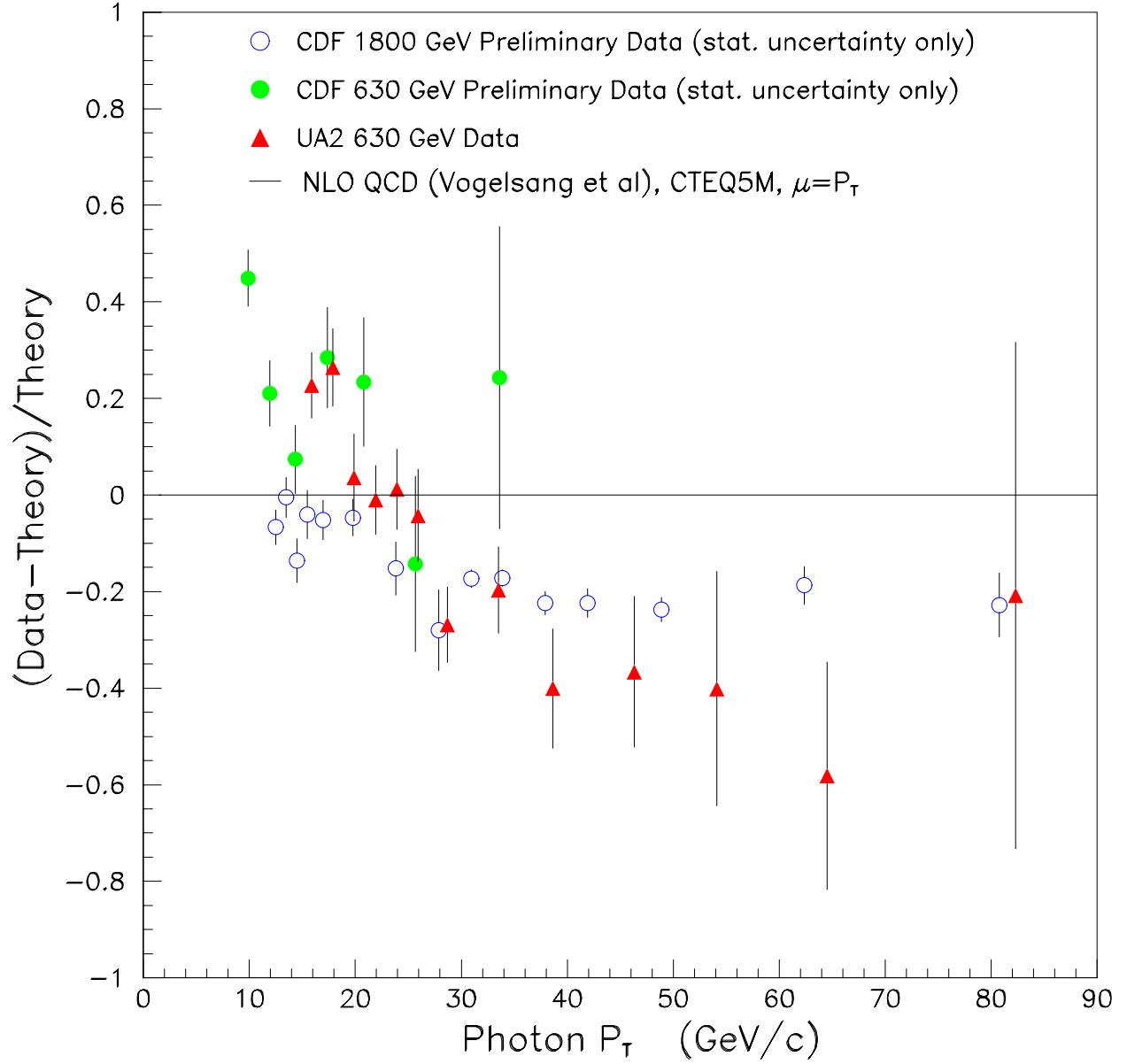


Figure 1. Theory normalized differential cross section for isolated photons from the 94-95 CDF data at 1800 and 630 GeV and UA2 at 630 GeV.

I.A.3 Non-Accelerator Physics at Soudan

a. Physics Results

The Soudan-2 detector continues to operate. Analysis of contained events and muons continues to shed new light on the atmospheric neutrino anomaly and the search for nucleon decay. One quite unexpected result in Soudan 2 has been the observation of strong seasonal effects. Recent interest in seasonal effects is due in part to the idea that Dark Matter could be at rest with respect to our galaxy. The sun is rotating around the galaxy and the earth's orbit around the sun is parallel (anti-parallel) to that motion in the winter (summer). The interaction of dark matter is expected to be velocity dependent, so there could be different rates of dark matter interactions through the seasons. Many other conceivable effects can be related to the seasons, and this turns out to be the case for Soudan 2.

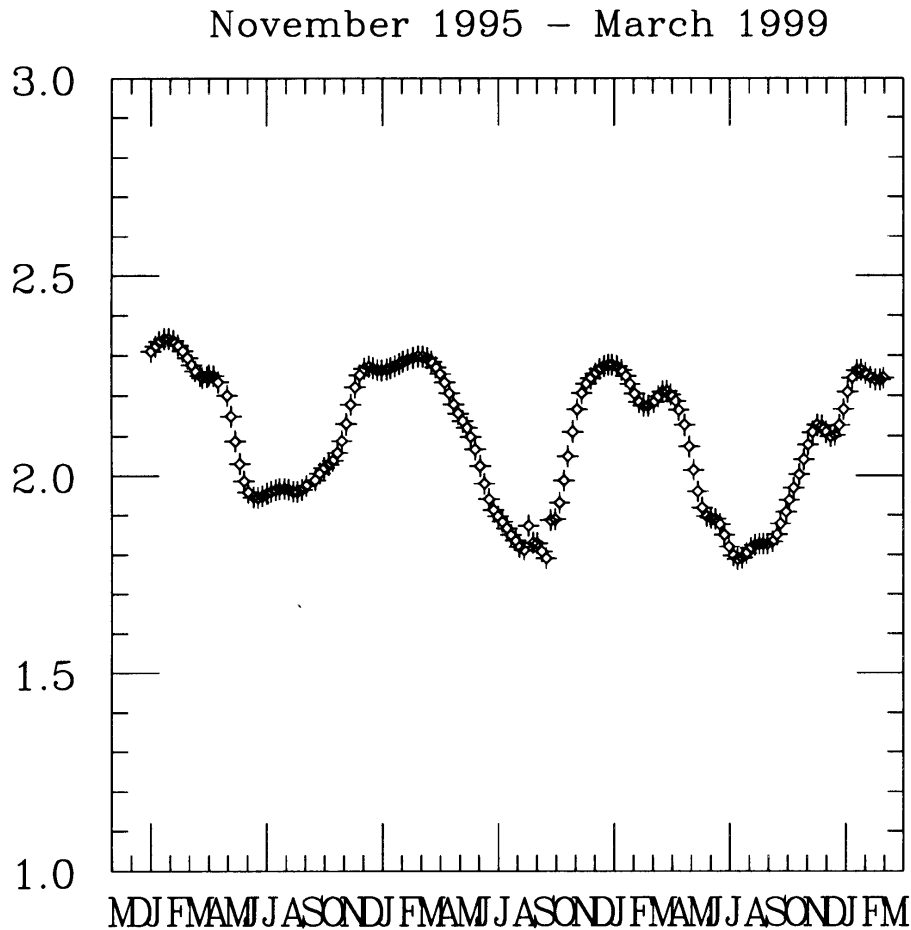


Figure 1. Average time between triggers versus month.

The Soudan 2-trigger rate has been found to have a very strong seasonal variation. This is shown in Figure 1. The trigger rate is about 30% higher in the summer than it is in the winter. This trend has continued for every season since the detector reached its full size in late

1995. A number of possible sources of this trigger variation were investigated. During the summer, many more physicists are working at the mine than in the winter. The notion that this kind of attention was affecting the detector response was quickly ruled out. A more credible scenario was that electronic noise could be higher in the summer than in the winter. The mine operates considerably more cage rides for tourists in the summer months. If this were related to the trigger rates, there should be a strong day/night effect in the summer, since the tours run only during the daytime. It was found that there was no day/night difference either during the summer or during the winter.

Another noise explanation was that there could be higher rates of noise on the electrical power lines. Electrical power certainly has strong seasonal aspects towards demand and the amount of noise on the lines might not affect others as it would our preamplifiers in Soudan 2.

Noise hits occur in either the anodes or cathodes but are not matched hits. Since the seasonal variation was so large, the noise hypothesis could be investigated in a small amount of data. About 2/3rds of the triggers are due to muons, and about 1/3 to “randoms”. A random trigger usually consists of 7 tube hits somewhere in the detector in which either the anodes or the cathodes were all found in the same electronics crate, due to multiplexing. This satisfies a locality feature of the trigger, even though the hits may not in reality be near each other. Runs during both the summer and winter were examined and it was found that triggered events were made up of real pulses which deposited energy on both the anodes and cathodes. Thus variations due to electronic noise were ruled out. The trigger variation was coming predominantly from anode crates and also predominantly in the outside wires along the east and west sides, and not from the top or bottom of the detector. This pointed towards an explanation related to Radon, and not photons from the Uranium and Thorium in the rock or concrete floor.

Radon measurements were carried out and compared to measurements made early during the construction of Soudan 2. It was determined that there are huge seasonal variations in the Radon levels, from typically 3 pC/l during the winter to about 12 pC/l during the summer. Soudan 2 has a ventilation system which gets fresh air from the mine, but this is not necessarily fresh with regard to Radon content. In fact, there are known to be large differences in ventilation and Radon levels in many other mines and caves between summer and winter because of various siphon effects which operate as the outside air temperature goes above and below the more constant inside air temperature. The variation in the Kamioka mine in the Radon level is a factor of 50.

The observed level of Radon, together with a measurement of activity from the rock, was compared to the singles rates. The result is that from 2% to 10% of the singles are due to Radon depending on the season. Since the variation in the random trigger rate goes as the 6th to 7th power of the variation in the singles rate, this is consistent with the observed variation.

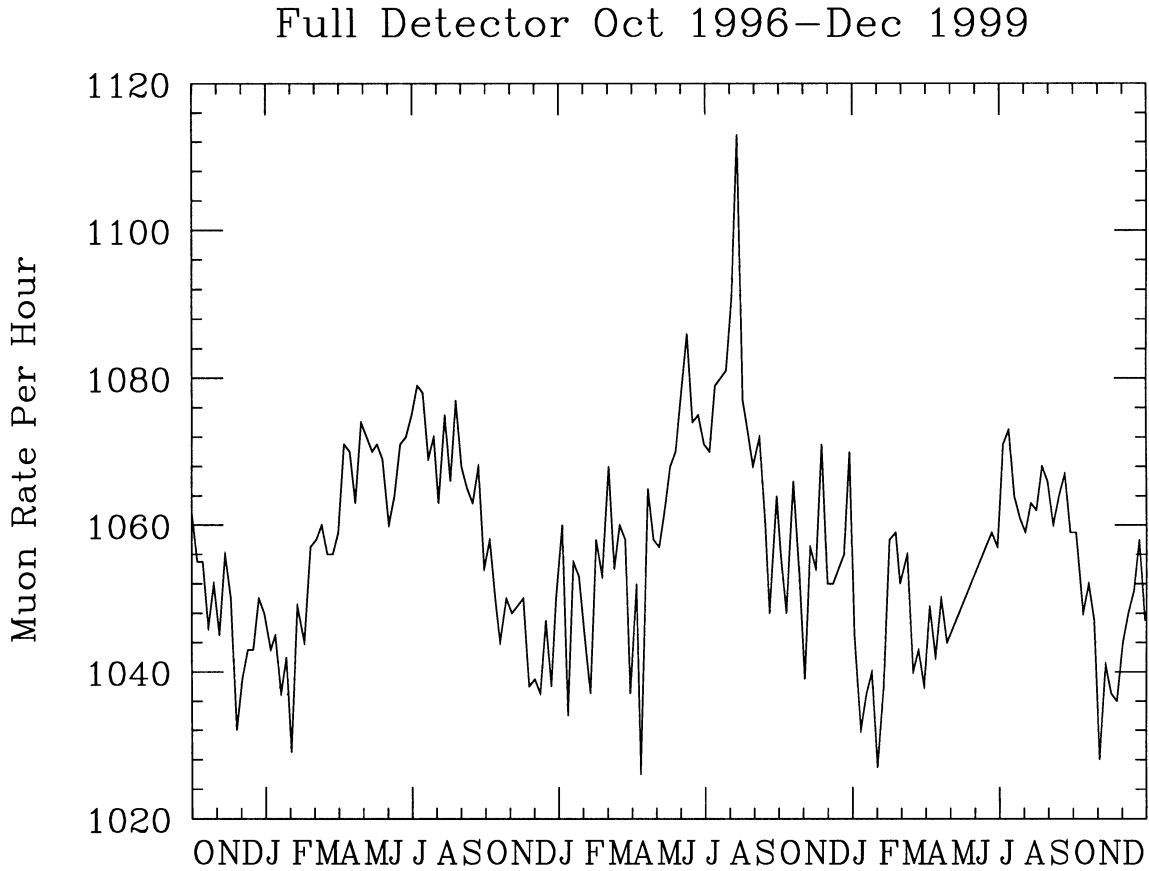


Figure 2. Muon rate versus month in Soudan 2

A second seasonal effect is observed in the muon rate. This change is smaller, $\pm 2\%$, but is more familiar to cosmic ray physics experiments. A graph of the reconstructed muon rate versus time is shown in Figure 2.

Atmospheric muons are created in the upper atmosphere. The average pressure, which depends on the total mass of the atmosphere, varies with daily fronts but averages out over periods as short as weeks. Of course the temperature of the upper atmosphere, where the muons are created, varies through the year, and this changes the density. The same number of pions are created throughout the year at a point of fixed overburden, or pressure. During a period of lower density (higher temperature, e.g. summer) the fraction of pions which decay rather than interact will increase, so there is an increased muon rate. The magnitude of this rate is similar in Soudan 2 to that in other experiments located at similar depths. In the absence of upper atmosphere temperature data, we do not perform a correlation, but there is no particular physics reason to do so.

(M.C. Goodman)

I.A.4 ZEUS Detector at HERA

a. Physics Results

Three papers were published in this period and seven more manuscripts were submitted for publication.

i) *Measurement of High Q^2 Neutral Current e^+p Deep Inelastic Scattering Cross Sections at HERA*

The e^+p neutral-current deep inelastic scattering differential cross sections $d\sigma/dQ^2$, for $Q^2 > 400 \text{ GeV}^2$, $d\sigma/dx$ and $d\sigma/dy$, for $Q^2 > 400, 2500, 10000 \text{ GeV}^2$, have been measured. The data sample of 47.7 pb^{-1} was collected in the years 1994 through 1997 at a center of mass energy of 300 GeV. The cross section, $d\sigma/dQ^2$, falls by six orders of magnitude between $Q^2 = 400$ and 40000 GeV^2 , see Figure 1. The predictions of the Standard Model based on the CTEQ4D parton density functions are in very good agreement with the data. Complementing the observations of time-like Z^0 contributions to fermion-antifermion annihilation, the data provide direct evidence for the presence of Z^0 exchange in the space-like region explored by deep inelastic scattering.

ii) *Measurement of Multiplicity and Momentum Spectra in the Current and Target Region of the Breit Frame in Deep Inelastic Scattering at HERA*

Charged particle distributions have been studied in the Breit frame in deep inelastic scattering over a wide range of Q^2 . The distributions in scaled momentum, x_p , and transverse momentum, p_t , have been measured for the first time in the target region of the Breit frame. For scaled momenta in the interval $0 < x_p < 1$, the mean target region charged track multiplicity is found to be larger than that measured in the current region. In the current region, the results show clear evidence for scaling violations in scaled momenta as a function of Q^2 and support the hypothesis of the coherent nature of QCD cascades. The data are well described by NLO calculations using NLO fragmentation functions derived from fits to e^+e^- data. The moments of the $\ln(1/x_p)$ spectra in the current region exhibit the same scale behavior as those observed in e^+e^- . The observed charged particle spectra are consistent with the universality of quark fragmentation in e^+e^- and DIS at high Q^2 , see Figure 2. Also shown is a comparison to the MLLA calculations based on the local parton hadron duality hypothesis. This approximation does not describe the data.

ZEUS NC 1994 – 97

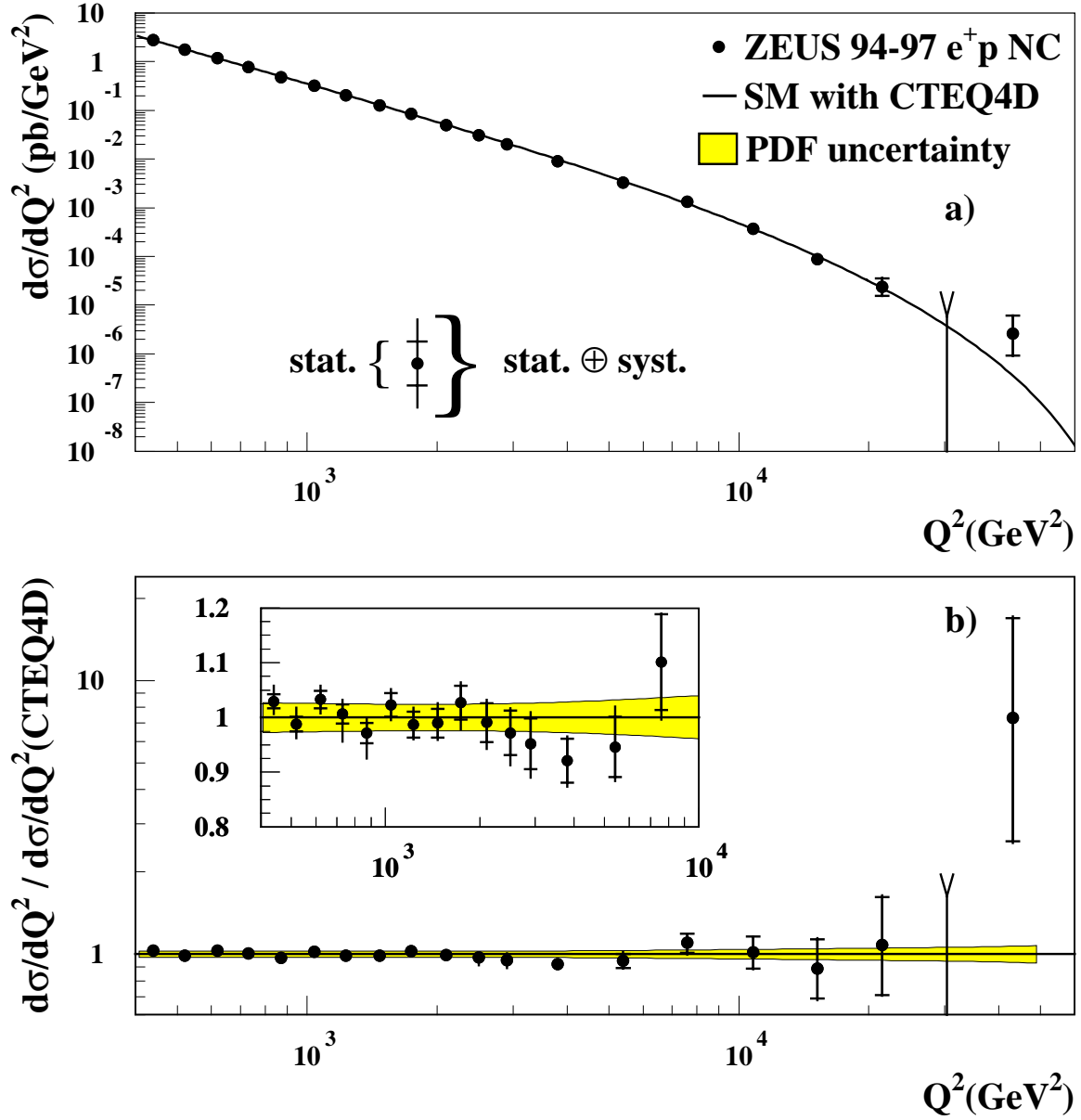


Figure 1. The high- Q^2 e^+p NC DIS cross section, $d\sigma/dQ^2$, for data (points with error bars) and the Standard Model predictions using the CTEQ4D parton momentum distributions (a). Also plotted is the ratio of data to the prediction (b). The inner error bars (delimited by the horizontal lines) show the statistical errors, the outer one the statistical and systematic uncertainties added in quadrature. The shaded region gives the uncertainty in the Standard Model prediction due to the uncertainty in the parton momentum distributions.

ZEUS 1994–1997

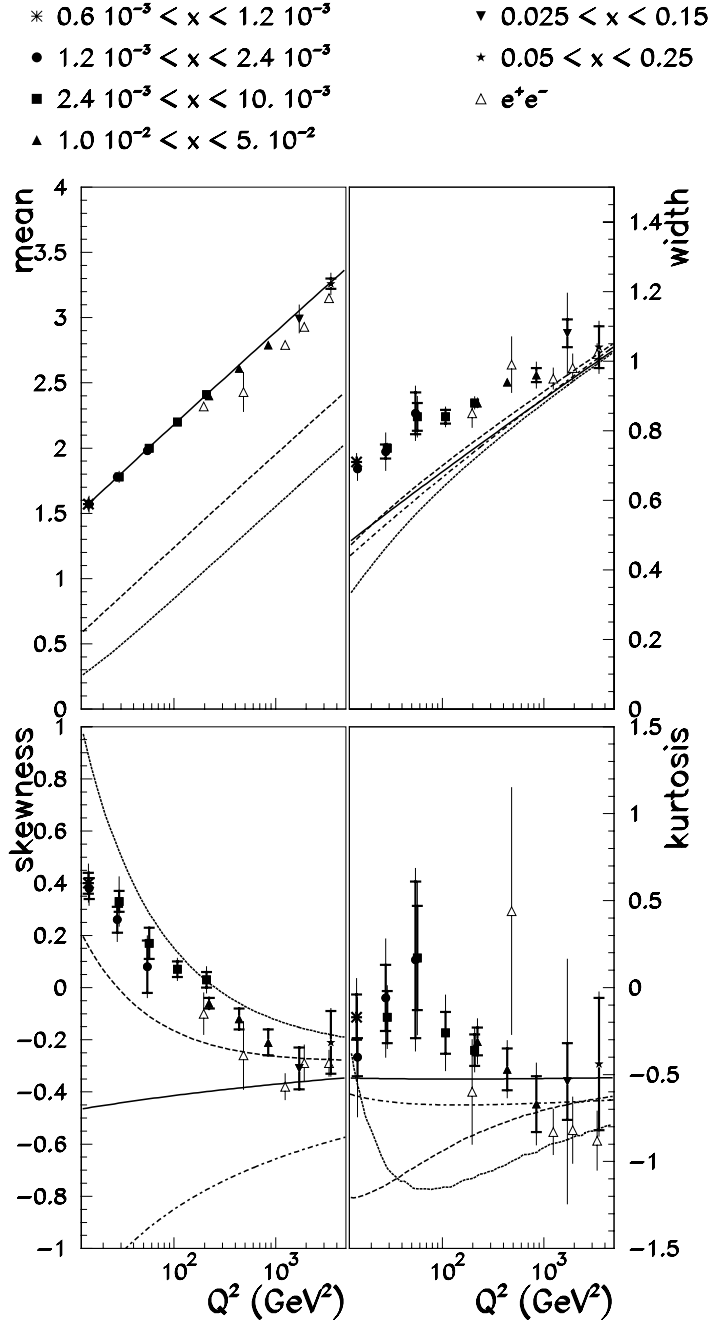


Figure 2. Evolution with Q^2 of the mean, width, skewness and kurtosis of the $\ln(1/x_p)$ distribution in the current fragmentation region. Data from e^+e^- and ep are shown together with MLLA predictions for different cut-off values $Q_0 = 1, 2, 3\Lambda$, where $\Lambda = 175 \text{ MeV}$.

iii) *Measurement of Dijet Photoproduction at High Transverse Energies at HERA*

The cross section for dijet photoproduction at high transverse energies as a function of the transverse energies and pseudorapidities of the jets has been presented. The cross sections have been compared to NLO QCD calculations. For the full accessible y range, $0.20 < y < 0.85$, the dependence on the transverse energy of the leading jet is generally well described by the calculations, although for events with two forward-going jets and $E_{T,\text{leading}}^{\text{jet}} < 25 \text{ GeV}$, the data lie above the NLO-QCD calculations, see Figure 3. However, in the region $x_\gamma > 0.75$, where x_γ is a measure of the fraction of the photon's momentum partaking in the production of the dijet system, the calculations agree with the measured cross section. In the high- y region, $0.50 < y < 0.85$, where a stronger sensitivity to the photon structure is expected, the cross section at central and forward pseudorapidities lies further above the predictions than for the full y range. Since theoretical uncertainties are expected to be small in most of the kinematic regime of this analysis, the discrepancies observed between the data and the NLO-QCD calculations suggest that, in the kinematic region of this analysis, the available parameterisations of the parton densities in the photon are too small.

b. HERA and ZEUS Operations

In the early part of calendar year 1999, HERA continued the electron run commenced in 1998. A total luminosity of 17.1 pb^{-1} was delivered in the first four months. Thereafter the machine switched back to positron running motivated by arguments related to different marginal deviations from Standard Model expectations observed in previous positron data. The machine performed exceptionally well and delivered an integral luminosity corresponding to 28.5 pb^{-1} .

The ZEUS detector performed well in this period. The recently added components, such as the forward plug calorimeter and the barrel presampler, were fully operational.

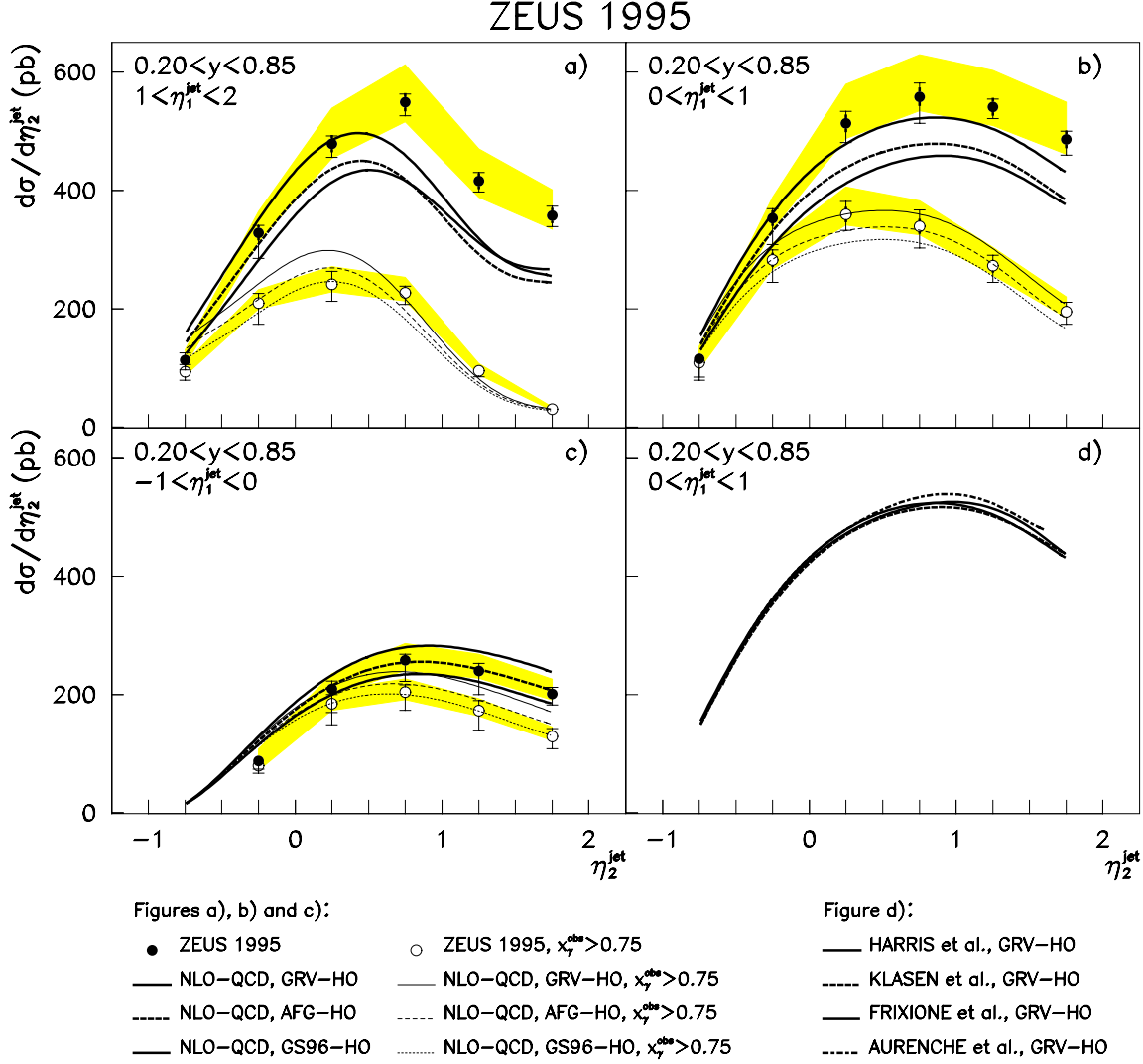


Figure 3. a), b) and c) show the dijet cross section as a function of η_2^{jet} in bins of η_1^{jet} . The filled circles correspond to the entire x_γ range while the open circles correspond to events with $x_\gamma > 0.75$. The shaded band indicates the uncertainty related to the energy scale. The different curves correspond to NLO-QCD calculations, using the GRV-HO, GS96-HO and the AFG-HO parameterisations for the photon structure. In d) the NLO-QCD results for the cross section when $0 < \eta_1^{\text{jet}} < 1$ and for a particular parameterisation of the photon structure are compared.

(J. Repond)

I.B. EXPERIMENTS IN PLANNING OR CONSTRUCTION

I.B.1 MINOS -Main Injector Neutrino Oscillation Search

The MINOS experiment is designed to search for neutrino oscillations with a sensitivity significantly greater than has been achieved to date. The phenomenon of neutrino oscillations allows the three flavors of neutrinos to mix as they propagate through space or matter. The MINOS experiment is optimized to explore the region of neutrino oscillation parameter space (values of the Δm^2 and $\sin^2(2\theta)$ parameters) suggested by previous investigations of atmospheric neutrinos: the Kamiokande, IMB, Super-Kamiokande and Soudan 2 experiments. The study of oscillations in this region with a neutrino beam from the Main Injector requires measurements of the beam after a very long flight path. This in turn requires an intense neutrino beam (produced by the new Fermilab Main Injector accelerator) and massive detectors. The rates and characteristics of neutrino interactions are compared in a “near” detector, close to the source of neutrinos at Fermilab, and a “far” detector, 730 km away in the underground laboratory at Soudan, Minnesota. The neutrino beam and MINOS detectors are being designed and constructed as part of the NuMI (Neutrinos at the Main Injector) Project at Fermilab.

The MINOS detectors are iron-scintillator sandwich calorimeters, with toroidal magnetic fields in their thin steel planes. The combination of alternating active detector planes and magnetized steel absorber planes has been used in a number of previous neutrino experiments. The MINOS innovation is to use scintillator with sufficiently fine transverse granularity (4-cm wide strips), so that it provides both calorimetry (energy deposition) and tracking (topology) information. The 5,400 metric ton MINOS far detector is also much more massive than previous experiments. Recent advances in extruded scintillator technology and in pixilated photomultipliers have made such a detector feasible and affordable for the first time.

Results from Super-Kamiokande, Soudan 2 and MACRO experiments provide increasing evidence that neutrino oscillations are taking place in just the regions of parameter space that MINOS was designed to explore. This has provided mounting impetus to go forward with MINOS as expeditiously as possible. Earlier indications from Super-Kamiokande data had raised the possibility that Δm^2 is below $10^{-3} eV^2$, but the latest data puts the best fit back up to $3.5 \times 10^{-3} eV^2$. Efforts at designing a lower energy beam to cope with lower values of Δm^2 have proved useful for some physics tests at this value of Δm^2 , so the beam spectrum when the experiment starts is a matter of continuing study. Argonne physicists have been primarily involved in three aspects of preparation for MINOS: scintillator factory development, front-end electronics, and the use of the Soudan 2 detector, also known as THESEUS.

Since an Argonne MINOS group member serves as WBS Level 2 manager for electronics, Argonne HEP has substantial responsibility for the front end electronics. Several decisions about front end electronics were made in the second half of 1999, driven in part by the increased possibility of having to use single turn extraction (STE) from the Main Injector. STE has significant implications for the near detector front end electronics since the events happen in a time frame about 100x faster than if resonant extraction were used. A readout chip which handles this rate is the QIE that was designed at Fermilab. The decision was made to use the QIE based system, to be designed at Argonne and Fermilab, for the near detector, and an IDE based readout for the far detector. Progress has already been made in the conceptual design of the near detector system based on the QIE. This device is capable of operating with a 53 MHz clock, with no deadtime associated with the digitization. The chip is pipelined to accomplish this. We are planning on starting with a version of the QIE that was developed for KTeV, and will make minor modifications to it to improve robustness and to take advantage of operational experience. The QIEs will be located as close as possible to the photodetectors. Digital data will be transmitted to a readout board in a VME crate, located some distance away.

The second major focus of work by the Argonne MINOS group is scintillator module production. Argonne performed engineering design and prototyping of critical parts of the scintillator detector system. As a result, Argonne was chosen as the future site for the production of near detector modules. Argonne physicists and engineers serve as NuMI Project Level 3 WBS Managers for the scintillator strip fabrication and for the design and construction of the machines needed to construct scintillator modules. Argonne finished work on a prototype production facility for scintillator "modules" in Building 366. That facility was used in August 1999 to produce scintillator modules for the 4-plane prototype at Fermilab. Based on experience obtained during this run, improvements to the glue machine were designed and implemented.

An Argonne MINOS group member also serves as WBS Level 2 manager for far detector installation. Far detector installation work during this period involved close interaction with the architect engineering firm, CNA Consulting Engineers and with Lametti Construction company, which started excavation for the new MINOS cavern. The Argonne installation group also continued to work on the design of installation procedures for the detector at Soudan, in close collaboration with the Soudan 2 mine crew and with CNA.

(M.C. Goodman)

I.B.3 ATLAS Detector Research & Development

a. Overview of ANL ATLAS Tile Calorimeter Activities

The TileCal subsystem realized many important objectives in the second half of 1999. The first of these was to overcome problems encountered with applying a protective paint to submodules which had resulted in excess layer thickness and frequent areas in which nodules of paint were left. Despite this, by investment of significant technical effort, the submodule construction rate came close to meeting the project goal by the end of the calendar year. Another major group of achievements were the mechanical assembly of the first production module, a successful test of the module transporter developed and built at Michigan State University (MSU), and shipment of the first module to MSU for instrumentation. The year was brought to a close by the mechanical construction of a second module, which was craned into the module instrumentation area to allow insertion scintillator tiles to begin. The tile insertion was completed by the end of the period and instrumentation work will resume in the coming year with insertion of the readout fibers. Finally, calorimeter construction is in full swing in Europe and the former Soviet Union. Although this work is somewhat behind schedule due to the delays in beginning submodule construction, most of the startup problems appear to have been encountered and overcome. The group is expecting to see smooth operations from early 2000 onward and some recovery of the schedule slippage.

(J. Proudfoot)

I.C. DETECTOR DEVELOPMENT

I.C.1 CDF Detector and DAQ Electronics Development

Shower max calorimeter readout continues to be a major project for us; Karen Byrum is project manager and Gary Drake is Chief Engineer, and John Dawson has taken on several of the components. All of the multiple card components except the preamplifier have gone into production. A preamplifier design has been tried with a few channels on our local test setup and looks promising. Jimmy Proudfoot is working on testing an internal programming development for the VME readout boards "SMXR". Steve Kuhlmann is continuing to develop software to handle the hardware within the B0 online system. Karen continues working with Gary to develop the amplifiers needed for the wire chamber shower max readout.

Karen and John have been working with the Michigan group to prototype the shower max Level 2 trigger bit input card; this has been demonstrated using level 2 emulation and a production version has been started. John is also working with the Yale group on the Level 1 interface to Level 2; a prototype of the card has been tested. Steve, John, and Bob Blair have prototypes of isolation trigger electronics which have been tested with the level 1 calorimeter input cards.

Larry Nodulman has continued working on shielding wire chamber signal cables and redoing the grounding. The last crack chambers which had high voltage problems were replaced. Steve Kuhlmann has been coordinating the new gas feed system for the wire chambers.

Bob Wagner and Randy Thurman-Keup are developing offline software for calorimeter reconstruction with emphasis on electron code. Bob, Steve, and Barry Wicklund are involved in code for the wire chamber data reconstruction. Bob Wagner has completed the program of fixing the bases and checking the tubes for the central EM calorimeter.

Randy Thurman-Keup is developing high voltage control for wire chambers other than COT, that is muon chambers as well as preshower, shower max and crack chambers in our calorimeter. Good progress continues on the muon upgrade, under the oversight of Tom LeCompte, with new front-end electronics and new chambers being completed and installed.

(L. Nodulman)

I.C.2 ZEUS Detector Upgrade

a. Straw Tube Tracker Readout Electronics

ZEUS plans to install a new forward tracking detector during the 2000/2001 machine shutdown. The new tracker is based on the straw tube technology and will consist of 48 sectors containing a total of 12,000 tubes. It is expected to greatly improve the detector's ability to measure high Q^2 neutral current events, to determine charged current event vertices, to tag heavy flavor decays in the forward direction, and to track charged particles in general. The detector is being built by a group of nine institutions which are all part of the ZEUS collaboration.

The Argonne group took over the responsibility of designing and building the front-end electronics consisting of shapers, discriminators, a multiplexing and a cable driver circuit. The multiplexing is necessary to match the 12,000 channels of the new detector to the 2,000-channel readout system of the current forward detector.

As a first step, Argonne built a prototype board containing the two-threshold ASDBLR chip developed by Penn University to shape and discriminate the signals and a circuit to drive the standard 42 m signal cable employed by the experiment.

Based on experience gained with the first prototype, a second prototype was built using the ASDQ chip, which contains a one-threshold discriminator. The second prototype contains all elements of the readout system, including the multiplexing circuitry and is very similar to the final production electronics. Extensive tests of the second prototype were performed in order to understand the threshold setting circuitry and the on-board pulser.

(J. Repond)

I.C.3 ATLAS Calorimeter Design and Construction

The ATLAS Tile Calorimeter construction effort is now fully into the production phase. The sub-areas of this phase comprise submodule construction, module assembly, instrumentation and testing, test beam measurement of detector performance, engineering support of work at US collaborating institutes, continued engineering evaluation of specific elements of the detector, and final design of areas in the detector where special constraints such as the support of the liquid argon cryostats must be accommodated.

a. Submodule Construction

In the late summer, submodule production commenced at full rate. At the close of this reporting period, 69 submodules were stacked and welded, 68 painted, and 52 fully completed and stored, ready for mounting into modules. This meets the production target. The Tile Calorimeter subsystem quality control was fully in operation, with QC sheets being filled out by technicians and then transferred to computer files by a group secretary. A major issue over the worldwide production effort is the submodule height, which is specified to lie within +0.3mm and -1.5mm of the design. The height envelope is shown in Figure 1 (for a large part of this production). Generally, the Argonne production

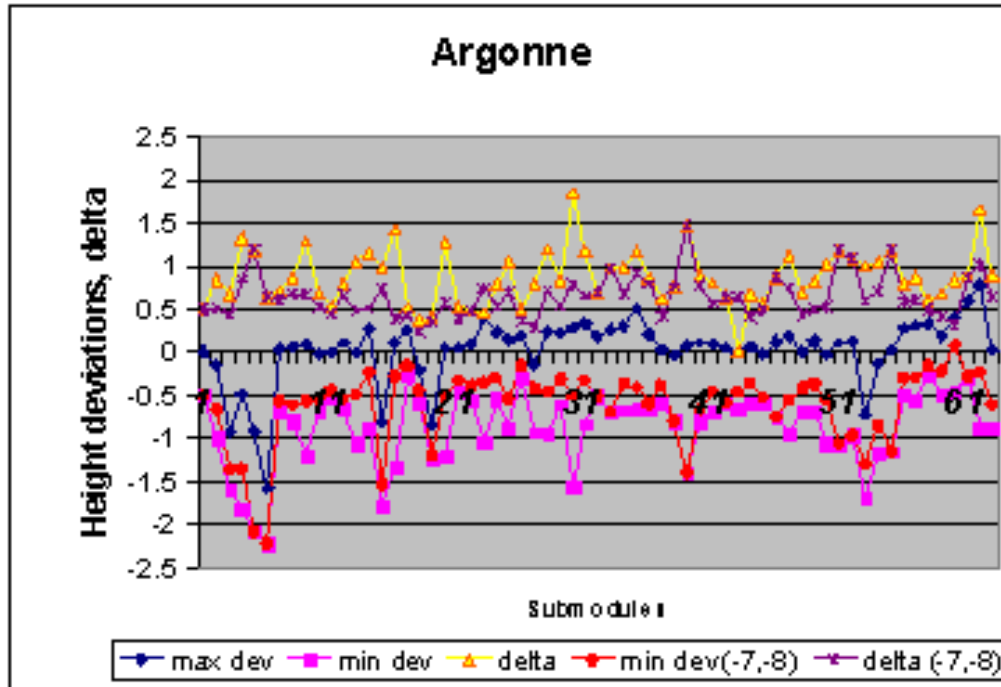


Figure 1. Submodule height envelope based on Tile Calorimeter global quality control measurements.

is well within the envelope, with most of the excursions occurring in the early submodules. Two main technical problems hampered the production effort. The first of these was with the application of a Tile Calorimeter standard protective paint. In addition to the paint thickness being poorly controlled, drips and the like tended to form. This was unacceptable and we carried out extensive and time-consuming studies to correct these problems in close communication with our other European and US collaborators. The problems were largely corrected by the end of this period. However, some 50 submodules required a significant (unplanned) level of effort to correct the problems and allow insertion of scintillator tiles and the readout fiber sleeves. A second technical problem arose which was more global within the US collaboration and related to the holes in the bars which are welded onto submodules and through which the submodule is subsequently bolted to the strongback girder. The problems comprised errors in positioning of the holes, in the quality of the cut threads, and in non-perpendicularity of the threaded hole. The fraction failing specification in one of these characteristics was as high as 25% on parts of the production. Following extensive exchange of information and tests, a meeting was held at Argonne to review the data and develop a corrective action plan. Several manufacturing errors were identified and, in addition, a more explicit quality control program was requested of the institution responsible for the production of the bars.

Some feedback was also obtained from the assembly of the two production modules built in this period and includes:

- minor levels of paint were found in bolt holes and key ways
- some epoxy was occasionally found in the outer radius key way

- the perpendicularity on girder key was generally very good

The production procedures have been updated where necessary to reflect these observations and the issues brought to the attention of the technicians performing the final quality controls on submodules.

b. Module Assembly

All tooling and procedures needed to assemble modules was brought into operation in this period. The work commences with cleaning of the strongback girder, followed by gluing in so-called girder-rings using a custom tool provided by one of our European collaborators, as shown in Figure 2. The assembly of modules is carried out on an assembly base, which also may be seen in Figure 2. A simple yet elegant alignment system was developed by Argonne technical staff to replace the scheme used for production of a prototype module. The basic ideas are indicated in Figure 3 and comprise: an optical transit, a precision transverse slide upon which the transit is mounted, a precision level and a calibration and alignment scheme using a plumb-line and a fixture to locate and sight the center of the submodule inner radius key. In addition, a precision 4-ft. square was fabricated for use in setting the submodules perpendicular to the girder.



Figure 2. Girder rings being glued into the strongback girder.

Two modules were fully constructed in this reporting period and a 3rd almost completed. Some problems (primarily with the azimuthal alignment) were encountered in the construction of the first module, which was rebuilt a number of times and took place over a period of about a month. During this construction the final details of the alignment fixtures were worked out and tooling developed as ideas came along. For the second module the work went much more smoothly and it is reasonable to expect that a module may be fully constructed and checked in less than 2 working weeks.

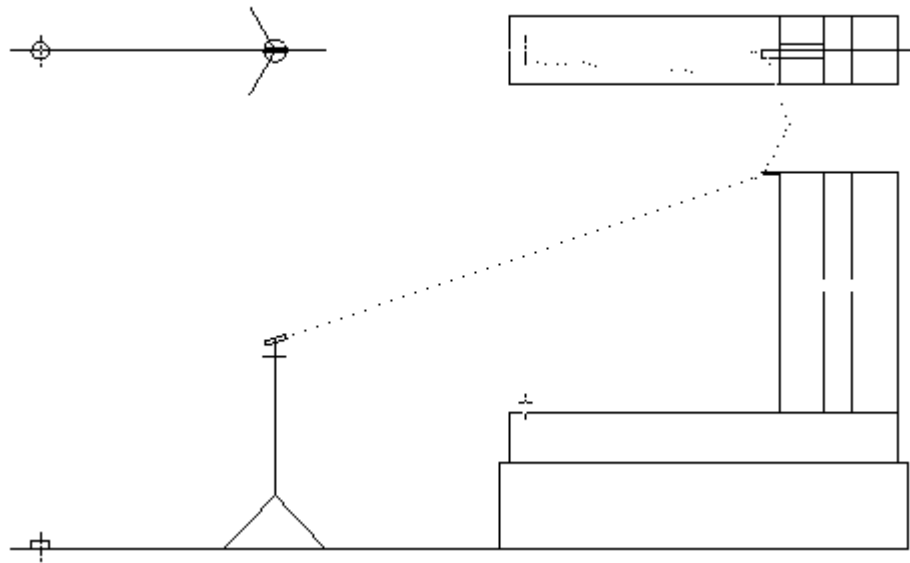


Figure 3. Module assembly alignment and mounting concept.

Module production is significantly behind schedule at the present time. Initial schedule delays were the result of delays in establishing the contract for the strongback girder. However, following the delivery of 2 girders in July, a subsequent 8 in November, and a regular production rate of 8 per 3 calendar months, this no longer is an issue. However, construction of one special type of submodule (ITC) is the responsibility of a US collaborating group and is substantially behind schedule due to a series of technical and fabrication problems. Delays in the production of these submodules are expected to continue into summer 2000 and will limit our opportunity to recover part of the schedule slippage in the immediate future.

c. Instrumentation and Testing

Due to the delays in constructing the first modules, there has also been a delay in start-up of module instrumentation and testing. However, in this period all of the supporting infrastructure was completed. This included clearing out the instrumentation room to allow installation of storage cabinets and shelves, installation of the assembly bases and lights with UV filters, and setup of the computer systems to be used for readout of electronics and control of the calibration source. In addition to writing draft procedures for instrumentation and testing, a large number of fixtures and tools to be used in instrumentation were completed.

- A large sheet metal stencil used to mark cell boundaries was laid out and fabricated.
- Two 3-dimensional fiber routing modules were constructed and cross-checked with those to be used at MSU and in Europe. An example section of one of these models is shown in Figure 5.
- The transporter required at MSU was tested and subsequently used to move Module 1 into their instrumentation area.
- The readout electronics and cesium source calibration systems were checked out and operating computers and software prepared.
- A light-tight tent capable of covering the entire module was fabricated and installed.
- An LED-based system for use in quality control of the fiber routing was designed and fabricated.



Figure 4. Module 2, the first module to be instrumented at Argonne, being lowered onto stands in the instrumentation area in Building 366.

The final work of 1999 was installation of all of the scintillator tiles into Module 2. Paint was still a problem and required some additional, minor clean-out. The only other issue of importance was the need to fabricate custom shims for the larger gaps between submodules. Both of these issues will be addressed earlier in the production phase for future modules.

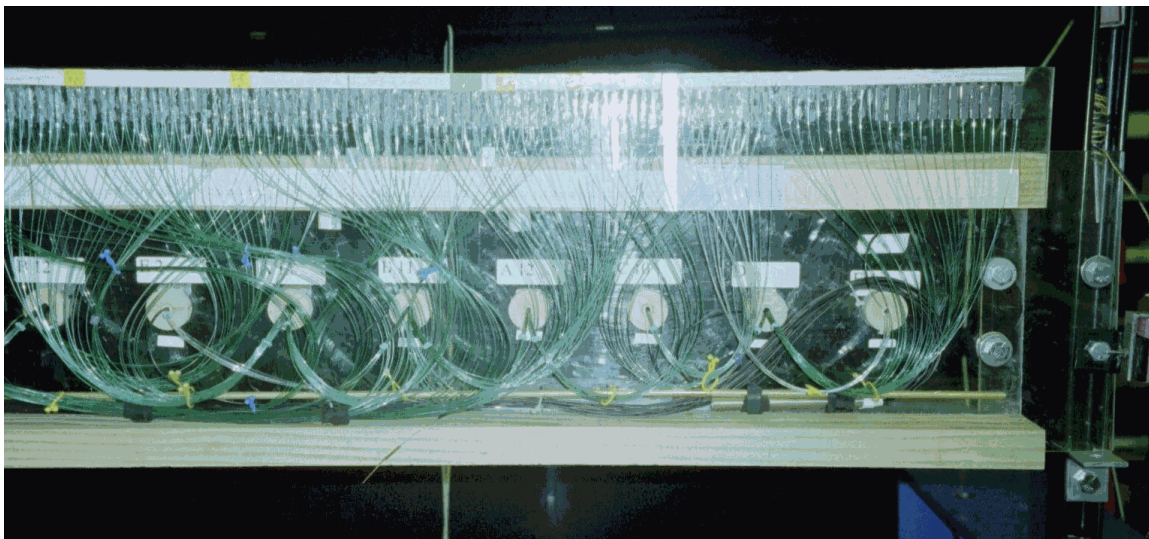


Figure 5. An example section of one of the two fiber routing modules constructed for use as part of the instrumentation procedures.

d. Engineering Support of US TileCal Collaborators

At the fall 1999 Atlas Week, Argonne technical staff raised an important question concerning stresses in the threads of the weld bars connecting submodules to the girder. In particular, the question raised the possibility that these stresses would fall significantly above those used elsewhere in our design for those submodules most severely affected by the additional load of the endcap liquid argon calorimeter. Analysis of these loads and of the impact on the weld bar threads was carried out in this period and the work included an interim meeting in October of several of the US groups and the Tile Calorimeter subsystem leader (M. Nessi). The issue is still open and the plan is to continue this work via email exchanges between the 4 lead Tile Calorimeter engineers and to review the results and determine a plan of action at the February 2000 ATLAS Week.

Design work on the special submodule used to support the liquid argon calorimeter cryostat resumed in the latter part of 1999. Some fabrication tests are planned for early 2000 and a decision on the approach to be adopted will be made in the spring of 2000. Review of assembly plans, as well as integration drawings and the impact of these on the special modules and submodules, has also begun and will be a focus of the Tile Calorimeter group such that final designs can be realized by the end of the year 2000.

Finally, Argonne scientific and technical staff have supported submodule construction activities at several US collaborating institutions. This support included:

- welder certification and WPS process assistance,
- weld strap QC and fabrication control,
- ITC construction and quality control,
- application of the protective paint,
- site checks of submodules at UI and UC,
- ITC plate preparation and shipping to UTA,
- materials shipping and handling from Europe (scintillator tiles, fibers, paint and small parts), and
- submodule quality control monitoring.

(J. Proudfoot)

I.C.4 MINOS Detector Development

During the second half of 1999, the Argonne MINOS group devoted a substantial effort to complete the development of procedures for the production of extruded scintillator strips, most of the assembly machines, quality control equipment and procedures which will be used at the scintillator module assembly facilities. ANL used its prototype factory during July and August of 1999, in order to both make scintillator modules for the 4-plane prototype, and to benchmark module production requirements and schedules. Important operational experience was obtained on a number of devices which were developed at ANL: the semi-automatic fiber gluer for placing the WLS fibers into the grooves of each 4 cm scintillator strip, the fly cutter to make very flat surfaces on the fiber optical connections to ensure high light transmission, and the module mapper which was used to move a radioactive source at varying positions above a module and measure its response.

Re-design of the glue machine took place concurrently with an evaluation of scintillator strip performance to ensure that no voids in the epoxy or misplacement of the fiber during the gluing process were causing any degradation of light output. Strips were glued and scanned in order to evaluate them for dips in light output. No major dips were found, and it was determined that minor dips were related to scintillator or fiber properties and not machine performance. A new base and main drive system were fabricated and a new production run is now scheduled for April 2000.

Other work involved design of the module curing racks and assembly tables. A prototype assembly tray was fabricated, using a new method of getting vacuum within the tray. In addition, a new vacuum tape was evaluated as a means of replacing the rubber gasket on the

prototype trays. This method should be faster, cheaper and more reliable. Extensive work was done to clear out old equipment and to make space for the pre-production prototype run in April. Agreement was reached regarding the plan for building modules, which will take place at Caltech, Minnesota and Argonne. A variety of plans for converting the prototype factory in building 366 into a near detector factory will be finalized after the next prototype run.

(M.C. Goodman)

I.C.5. Electronics Support Group

CDF. We continued with our work in the development of front end electronics for the Shower Max Detector of the CDF Upgrade at Fermilab. For this project, we have overall responsibility for the electronics engineering of the system. The major responsibility in this project involves the coordination of the design engineering and system integration for the entire system. This includes the development and integration of all front end boards and crates, and the read-out board that interfaces to the upper levels of the data acquisition system. The development work is a collaborative effort between Argonne and Fermilab.

In addition, we have specific responsibilities for the design and production of several components of the system. One project is the specification and qualification of the custom integrated circuit for the front end electronics, called the SMQIE, which was designed at Fermilab. Last year, we completed the testing on the final prototype chip, and gave the approval for the production of ~20,000 chips. We received the packaged parts in September 1999. The production chips were tested at Fermilab. The production was highly successful, and we achieved the desired performance and yield.

Argonne is also responsible for the design, testing, and production of the daughter boards that contain the SMQIEs, called the SQUID. Each SQUID contains two SMQIEs, and other support circuitry for calibration. Several prototypes were designed previously, and used for testing earlier prototype chips. The design of the new board was completed in the spring, and tested with the production chips. The production of 6500 boards will begin in early 2000. The boards will be tested at Fermilab, with oversight by Argonne personnel.

Another project is the design and production of a VME-based readout board, called the SMXR. This is a sophisticated data processor. It receives digitized data in floating-point form from the front end electronics at the rate of 300 MByte/Sec, adds together up to four words as sampled in time to reconstruct long signals from the detector spread out in time, and also forms trigger bits from the reconstructed signal. The data is stored in a buffer pending read-out by the data acquisition system. The first prototype was developed in the early part of 1998, and the design of a second prototype was completed in early 1999. Testing is in progress. Production of 100 boards will begin in early 2000. The boards will be checked out at Argonne.

Another project is a preamp for the Central Electromagnetic Strip (CES) Detector. The SMQIEs will be used to read out signals from the CES, but additional gain is needed to boost the signal into the range of the device. The preamp receives the charge signal from the detector, amplifies it, and provides filtering to reduce noise pickup. Several prototype versions have been completed to date, but have had marginal noise performance. A new design is in progress that should meet the noise specifications. The new design will be tested in early 2000.

For the system integration, work is in progress to do system testing at both Argonne and Fermilab. This testing will be the final shakedown of the prototype electronics before production. Much of this effort requires the generation of software, which is being written by Argonne physicists. Argonne is taking the lead role in defining and executing the qualification testing of the prototypes as a prerequisite before production.

In addition to the Shower Max electronics, we are also involved with two other projects for the CDF Upgrade. In one project, we are designing and building electronics that can trigger on isolated photons, called ISOPICK. The board executes algorithms on a group of hit channels in a detector region that might contain an “interesting” event, and sends the result to the second level trigger as part of Level 2 trigger decision. The other project is the interface of the Shower Max system with the second level trigger, called RECES. This board receives data from the SMXR over a fiber-optic link. It is used to correlate signals from the Central Tracking Detector with signals from the Central Shower Max Detector. This aids in discriminating events containing electrons from other background events, such as hadronic showers or events with pions. Both boards are data processors, and are designed with extensive use of high-density programmable logic. Both the RECES and ISOPICK have been through a prototype stage this last year. Several design problems with each were found and fixed. The boards are currently being used in system tests. The final production is expected to begin by early spring of 2000, with installation complete by the summer.

ATLAS. We have major responsibilities in the development of electronics for the Level 2 Trigger of the ATLAS Detector at CERN. Working with colleagues from Michigan State University, we are responsible for the development of two parts of this system: the Level 2 Trigger Supervisor, and the Region of Interest (ROI) Builder.

The Trigger Supervisor controls all activity in the Level 2 System, including the allocation of Level 2 Processors and the passing of selected events to the Event Builder. This was originally designed as custom hardware, capable of operating with a variety of computers and bus interfaces. Argonne designed and produced this first board as custom hardware. It was used in many of the early tests to study system architecture. The current plan for implementation of the Trigger Supervisor in the final system is to use commercial processors, since the system architecture is now finalized. Argonne will provide software support for the final implementation.

The ROI Builder collects and processes information passed from the first level trigger that describes where data from an “interesting event” can be found. It passes this "record" to the Trigger Supervisor, which then distributes the information to one of several Level 2 Processors. The selected processor uses the information to collect the data fragments. It then executes algorithms on the data, producing a Level 2 Trigger Decision for that event.

In late 1998, we built the first prototypes of the ROI Processor and Input Card. The ROI Processor was fully functional, but the Input Card did not have a real interface to the Level 1 system, since that protocol had not yet been defined. The Input Card did have the capability to have data down-loaded to it. This allowed the boards to be used for system tests, by sending data that mimics real Level 1 data to the ROI Processor through this path. The prototypes were sent to Saclay in early 1999 for testing. The boards were used in their Test Bed, which contains several computers networked together as a small Level 2 Trigger System. Later in 1999, the ROI Builder was sent to CERN for additional testing with the system there as part of the Pilot Project. The tests are currently in progress.

In late 1999, we began the design of the second version of the Input Card. This version will have a real interface to the Level 1 Trigger System, which uses a serial protocol developed at CERN called S-Link. The board will be built in early 2000, tested at Argonne, and then shipped to Rutherford Appleton Laboratory in England for tests with prototype Level 1 components.

MINOS. We continued our involvement with MINOS, a Neutrino Oscillation Experiment at Fermilab (the Near Detector) and the Soudan mine (the Far Detector.) In late 1998, we took over Level 3 Management of the front-end electronics for both the Near and Far Detectors. In collaboration with Fermilab, we also had the responsibility for the design and production the electronics as well. In the early part of this year, we began the conceptual design of the front end electronics for both the Near and Far Detectors. By the summer of 1999, we had completed the conceptual design, including cost and schedules.

In the summer of 1999, the project management was asked to accommodate a change in the characteristics of the beam that will be delivered from Fermilab. The change involved increasing the instantaneous intensity of protons delivered during the spill by a factor of 100, while keeping constant the average number of spills per second. This meant that the front-end electronics for the Near Detector would have to be much faster than originally planned. The impact on the electronics for the Far Detector was minimal, because the event rate per spill is very low there.

By the fall of 1999, the collaboration decided to use a type of electronics in the Near Detector that had been developed for other high-rate experiments at Fermilab. The electronics uses a custom integrated circuit designed at Fermilab, called the QIE. The device has been used in KTeV and CDF. It can operate with a 53 MHz clock, which is what is needed to

measure events in the Near Detector with the new beam structure. Because QIE electronics is much more expensive than the electronics as previously planned, a less expensive solution was needed for the Far Detector to compensate for the higher costs. It was decided to use a different custom chip for the Far Detector, called Viking. It was developed by the IDE Company of Norway. It has lesser performance than QIEs, but has a low cost per channel. This solution accommodates the new beam structure at a modest cost increase for the electronics, but has the consequence that the front-end systems would now be very different between the Near and Far Detectors.

Because the electronics development was now split into two parts, it was decided to bring in more groups and divide up the responsibilities. Argonne took on a leadership role for the front-end electronics in the Near Detector, and accepted responsibility for Level 3 Management. Fermilab and Argonne have joint responsibility for the design, development, and production of that system. This choice leveraged the extensive experience that Argonne and Fermilab have had with QIEs. Harvard University accepted responsibility for the Level 3 Management of the front-end electronics for the Far Detector. Harvard and Oxford University will design and produce that system.

Following this change, we began work on the conceptual design for the new front-end electronics in the Near Detector. The QIE digitizes continuously at 53 MHz. The digitized data will be stored in a local memory during the entire period of the spill. The data will be sent from the local memory to a VME read-out board after the spill is over. In between spills, the electronics will record data from cosmic rays. The QIEs and associated circuitry will be built on small daughter boards resembling memory SIMMs. The VME read-out board will be a redesign of the SMXR designed for CDF.

The chip design, and the development of the QIE daughter board, are responsibilities of Fermilab. Argonne will design the VME read-out board, and the mother boards that host the QIE daughter boards. We also have overall responsibility for the design of the rest of the system for the Near Detector, including the specifications for the QIE performance.

We went through an internal review of the front-end electronics in November 1999, which was successful. We have now begun specific design tasks. In order to optimize the performance, we have specified changes to the QIE. The ASIC Design Group at Fermilab has begun this work. We have also begun specifying the interfaces between the front-end electronics and other subsystems. Our goal is to develop first prototypes in calendar year 2000, and plan for small system tests in early 2001.

ZEUS. The ZEUS at DESY is presently preparing a series of upgrades to the detector, which will be installed in late 2000. One of the upgrades is the replacement of the

Transition Radiation Detector (TRD) in the forward region, with a new one built using straw tubes. Argonne is leading the design effort to build the front-end electronics for the new detector, which will contain 12,000 channels. The electronics will use a custom integrated circuit designed at the University of Pennsylvania called the ASDQ. The chip processes the analog signals from the detector, and produces discriminated digital outputs as a function of a programmable threshold. The electronics multiplexes the output from six detector channels into one readout channel, to reduce the number of cables and associated electronics in the back end part of the system. The front-end electronics will be located inside the detector, where space and cooling are limited. It must be very low power, and be built using small surface-mount parts.

In late 1998, we built a test board that contained the custom chips, but none of the output multiplexing circuitry. It was sent to DESY, and tested with the prototype detector in a test beam. The electronics functioned well, and tracks were clearly seen in the detector. Improvements and changes were identified, and the final board sizes were defined. In the summer of 1999, we designed and built a new prototype that closely resembles the final implementation. The boards were delivered to DESY at the fall of 1999. Testing is currently in progress. The final board design will begin in the spring of 2000. The checkout of production electronics will be a collaborative effort between Argonne and Tel Aviv University.

Another upgrade that we are involved with for ZEUS is to replace the Cockcroft-Walton photomultiplier bases in the calorimeter. The bases use a novel design for generating 2000 Volts for the cathode of the photomultiplier from 24 Volts supplied as the input. The design is very compact, and fits in to a cylindrical can approximately 4 centimeters in diameter and 6 centimeters in length. The old bases are about 10 years old, and many have now failed in the detector. Replacement bases from the original manufacturer are no longer available. We are leading the effort to design a new base using modern surface-mount components.

In the summer of 1999, we built a test board that contained our new Cockcroft-Walton design, although it did not have the final packaging. The board went through a series of tests, and showed good performance. Following that, we began the design of the first prototype, which does have the proper packaging. We have now completed that design, and the boards are presently being fabricated. We plan to build several bases for testing at DESY in the early part of 2000. Ultimately, about 1000 bases will be produced. The production will be a collaborative effort between Argonne and Penn State University. We hope to begin the production by the summer of 2000, and try to install new bases before the shutdown in the fall. The bulk of the installation will occur during the fall shutdown.

(G. Drake)

II. THEORETICAL PHYSICS PROGRAM

II.A. THEORY

II.A.1 Spin Dependence of Massive Lepton Pair Production in Proton-Proton Collisions

Edmond L. Berger, Lionel E. Gordon (Hampton University), and Michael Klasen computed the transverse momentum distribution for the production of massive lepton-pairs in *longitudinally polarized* proton-proton reactions at collider energies within the context of perturbative quantum chromodynamics.

In Argonne report ANL-HEP-PR-99-97 (hep-ph/9909446), accepted for publication in Physical Review D, they show that for values of the transverse momentum Q_T greater than roughly half the pair mass Q , $Q_T > Q/2$, the differential cross section is dominated by subprocesses initiated by incident gluons, provided that the polarized gluon density is not too small. They conclude that massive lepton-pair differential cross sections should be a good source of independent constraints on the polarized gluon density, free from the experimental and theoretical complications of photon isolation and from the fragmentation uncertainties that beset studies of prompt photon production. They provide predictions for the spin-averaged and spin-dependent differential cross sections as a function of Q_T at energies relevant for the Relativistic Heavy Ion Collider (RHIC) at Brookhaven, and they compare these with their next-to-leading order predictions for real prompt photon production at the same energies. Ed Berger presented the results of this research in an invited talk at the Circum-Pan-Pacific RIKEN Symposium on High Energy Spin Physics, November 3-6, 1999, RIKEN Laboratory, Wako, Japan. This research on spin-dependence of the Drell-Yan process extends earlier work by the same authors on the *spin-averaged* cross section, published in Physical Review **D58**: 074012 (1998), (hep-ph/9803387) and in Nucl. Phys. B (Proc. Suppl.) **82**, 179-184 (2000), (hep-ph/9906402).

(E. L. Berger)

II.A.2 Physics Opportunities at the Fermilab Tevatron and the LHC

Edmond L. Berger has been an active participant in recent workshops in which physics opportunities in supersymmetry, top quark physics, and quantum chromodynamics (QCD) were explored for Run II at the Fermilab Tevatron collider and for the LHC at CERN. He was a theory co-convenor of the Working Group on Photon and Weak Boson Production as part of the 1999 year-long Workshop on Physics at Run II at the Fermilab Tevatron: QCD and Weak Boson Physics. The lengthy report of this working group is available as hep-ph/0005226. Along with Tim Tait, Berger studied the pair mass dependence near threshold of top quark pair

production as a means to measure the *spin* of the top quark in events from hadron collisions. As a byproduct, Berger and Tait discuss the possibility that a top squark signal could be hidden in the sample of events associated with the top quark. Their paper, ANL-HEP-CP-00-014 (hep-ph/0002305), was contributed to the Thinkshop on Top-Quark Physics for the Tevatron Run II, Fermilab, October 16-18, 1998, and is included in the chapter **Top Quark Physics** to appear in the *Report of the 1999 CERN Workshop on SM Physics (and more) at the LHC*, Geneva, October, 1999 (hep-ph/0003033). Along with Brian Harris and Zack Sullivan, Berger studied single top squark production via a baryon-number violating (R-parity violating) coupling and made predictions for cross sections and signatures of this process for Run II of the Tevatron. Their paper, ANL-HEP-CP-99-40, is included in the chapter entitled **Searching for R-Parity Violation at Run-II of the Tevatron** (hep-ph/9906224) to appear in *Physics at Run II Workshop: Supersymmetry/Higgs*. Working with Michael Klasen, Berger studied lepton-pair production (the Drell-Yan process) at both the Tevatron and the LHC with a view towards further constraining the gluon parton density in the proton. Their contributions, ANL-HEP-CP-00-002 (hep-ph/0001127) and ANL-HEP-CP-00-009 (hep-ph/0003211), are included in the chapter **QCD** to appear in the *Report of the 1999 CERN Workshop on SM Physics (and more) at the LHC*, Geneva, October, 1999, (hep-ph/0005025) and in the summary report of the working group on parton densities of the Workshop on Physics at Run II at the Fermilab Tevatron: QCD and Weak Boson Physics.

(E. L. Berger)

II.A.3 Higgs Boson Production

Several members of the Argonne theory group were very active in the Higgs working group of the Physics at Run II -- Supersymmetry/Higgs Workshop held at Fermilab.

B. W. Harris [with Howard Baer (Florida State) and Xerxes Tata (Hawaii)] studied the Higgs boson reach for CERN LEP2 and Tevatron luminosity upgrades for three models of weak scale SUSY: the Minimal Supersymmetric Standard Model (MSSM), the minimal Supergravity model (mSUGRA) and a simple Gauge Mediated SUSY Breaking Model (GMSB).

Z. Sullivan [with D. Dicus (UT, Austin), T. Stelzer, and S. Willenbrock (UIUC)] argued that the leading-order subprocess for Higgs-boson production in association with bottom quarks is $b\bar{b} \rightarrow H$. This process is an important source of Higgs bosons with enhanced Yukawa coupling to bottom quarks. They calculated the corrections to this cross section at next-to-leading-order in $1/\ln(m_H/m_b)$ and α_s and at next-to-next-to-leading order in $1/\ln(m_H/m_b)$.

T. Tait [with C. Balazs, H. J. He, C. P. Yuan (Michigan State), and J. L. Diaz-Cruz (Pueblo)] studied the discovery reach of the Tevatron and the LHC for detecting a Higgs

boson, predicted in composite models of the electroweak symmetry breaking or in supersymmetric theories, with an enhanced b -quark Yukawa coupling.

C. Wagner [with M. Carena (Fermilab) and S. Mrenna (UC, Davis)] studied the properties of the Higgs boson sector in the MSSM, putting special emphasis on radiative effects which can affect the discovery potential of the LHC, Tevatron and/or LEP colliders. They concentrated on the $Vb\bar{b}$ channel, with $V=Z$ or W , and on the channels with diphoton final states, which are the dominant ones for the search for a light Standard Model Higgs boson at LEP/Tevatron and LHC, respectively.

(B. W. Harris)

II.A.4 Mediating Supersymmetry Breaking Through Transparent Extra Dimensions

David Kaplan, along with collaborators Graham Kribs (Carnegie Mellon University) and Martin Schmaltz (SLAC), has constructed a supersymmetric model with a small, extra dimension. Supersymmetry could potentially explain why the weak scale is so low compared to what may be more fundamental scales, such as the grand unified and Planck scales. However, supersymmetry broken at the weak scale generically gives disastrous contributions to lower energy “flavor-changing” phenomena such as $K - \bar{K}$ mixing, $\mu \rightarrow e\gamma$ and others. Kaplan and his collaborators found that if there existed a small (one-hundred Planck lengths or so), extra dimension in which the gauge bosons and their superpartner gauginos live while matter fields are confined to hypersurfaces, all of these problems can be avoided.

The key is to have standard model matter (plus superpartners) located at a different point in the extra dimension from the supersymmetry breaking sector. The results are significant gaugino masses and negligible scalar masses at high scales. Running parameters to the weak scale using the renormalization group, one finds positive squared scalar masses of the same order as the gaugino masses. Because scalar masses come mostly from renormalization group effects involving gauge couplings, soft parameters are nearly flavor diagonal at the weak scale and, thus, no dangerous flavor-changing, neutral currents are produced. If one assumes CP is only violated on our hypersurface, there are no dangerous contributions to the electric dipole moments of, for example, the electron or the neutron. In short, this model may be the simplest way to mediate supersymmetry breaking while avoiding all current experimental bounds.

(D. Kaplan)

II.A.5 Photoproduction of Jets, Hadrons, and Prompt Photons

Photoproduction and deep inelastic scattering (DIS) are two of the most important processes investigated at HERA in events with many different final states. Whereas jets are most copiously produced, hadrons and photons offer a different physics potential for studies of hadronization and the photon and proton parton densities. In a recent workshop contributions, the status of next-to-leading order (NLO) quantum chromodynamics (QCD) calculations of all three types of photoproduction cross sections (M.Klasen) and DIS charmed hadrons (B. W. Harris) was reviewed, and the theoretical predictions were confronted with recent experimental data from the HERA experiments H1 and ZEUS. Additionally, detailed comparisons of our existing NLO jet photoproduction codes were made.

(M. Klasen and B. W. Harris)

II.A.6 Computational Physics

With CERN experiments looking at relativistic heavy-ion collisions and with the commissioning of RHIC due very soon, our efforts continue to be concentrated on projects aimed at understanding what QCD predicts for hadronic/nuclear matter at high temperatures and/or baryon number densities, since such an environment is expected to be produced in relativistic heavy ion collisions. In particular, one might hope to see transitions to new states of matter such as the quark-gluon plasma or one with diquark condensates. For these studies we are performing simulations in lattice QCD and model field theories.

For hadronic matter at non-zero baryon number density (chemical potential), the fermion determinant of QCD becomes complex and current simulation methods fail. Thus we have turned to the study of simpler field theories having some of the properties of QCD, which we can simulate with non-zero fermion number density. In particular, we are performing simulations of a 2-color version of QCD in order to study the formation of diquark condensates in a confining theory. Such condensates have been suggested for QCD at finite quark number density, where they would spontaneously break color symmetry leading to “color superconductivity”. Having reported evidence for such condensates in the previous 6-month reporting period, we have worked to produce code to observe and measure the Goldstone modes associated with such a spontaneous symmetry breakdown and to look at the competition between chiral and quark number symmetry breaking in this model. Because the Cray SV1's on which we are currently running are too slow for these mass calculations, we have developed parallel MPI code on the NPACI IBM SP, which will be run in production on the new IBM SP's at NERSC and NPACI when they become available in early 2000.

Our simulations of lattice QCD with zero quark masses at finite temperature are coming to an end. These simulations augment the standard, staggered quark action with a chiral

4-fermion interaction, which makes zero quark mass simulations possible. Our simulations on lattices with temporal extent 6 on the Cray SV1's and Cray T3E at NERSC, which are nearing completion, will yield the best determination to date of the critical indices at the transition from hadronic matter to a quark-gluon plasma. Here it is important to know if these indices are those of certain 3-dimensional spin models, as suggested by universality arguments. If so, it would indicate that the nature of the transition is determined from symmetry arguments alone and not on the details of QCD dynamics. Figure 1 shows the time history of a simulation at a $\beta=6/g^2$ just below the transition. The long, time-constant fluctuations (At finite quark masses, runs of a few thousand time units were adequate.) indicate the critical slowing down close to a critical point.

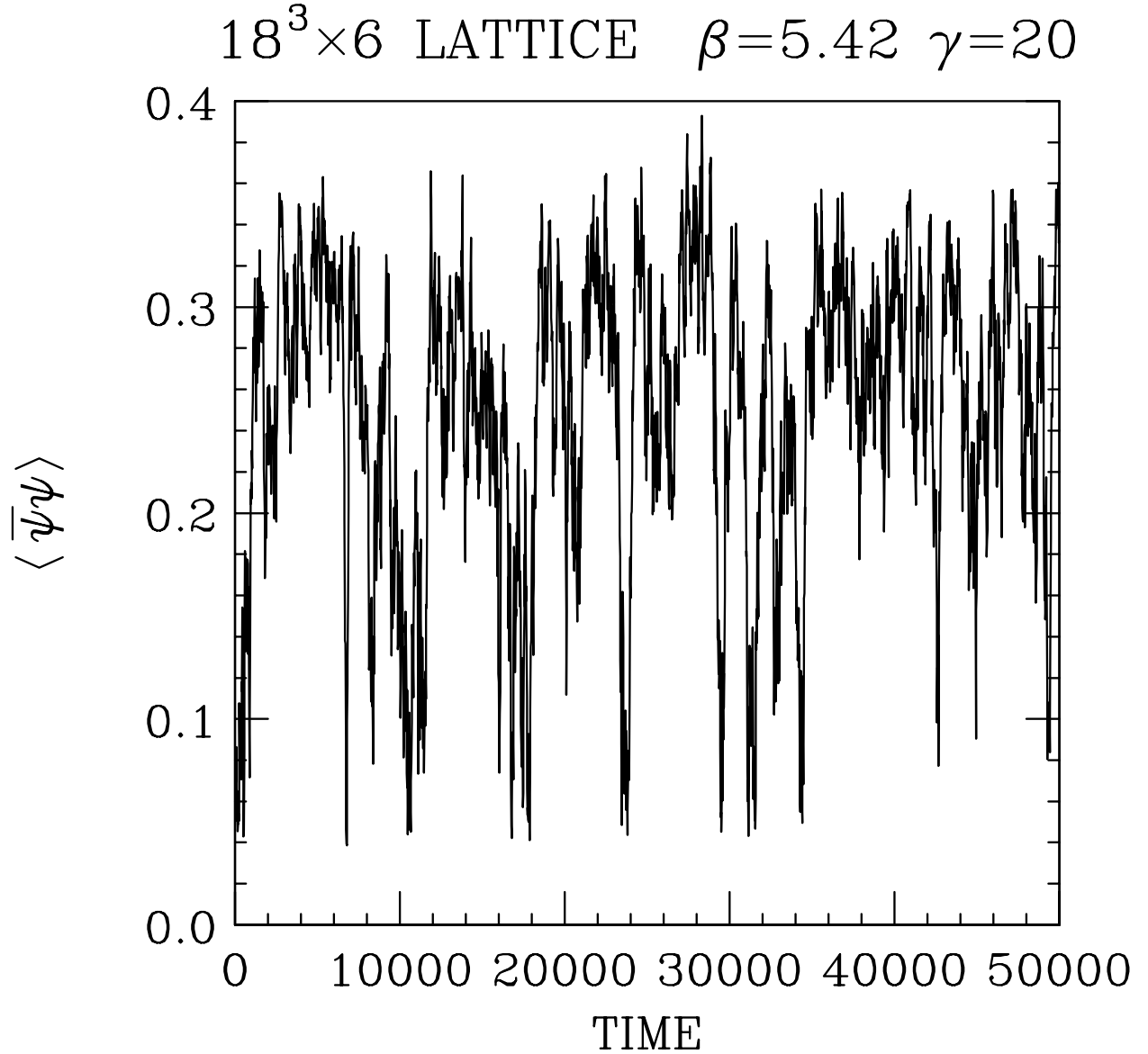


Figure 1. Time history of the chiral condensate at $\beta=5.42$.

In addition, we are continuing our work testing the behavior of domain-wall quarks, which allow a systematic approach to truly chiral quarks in the high temperature domain of lattice QCD. Following the successes we saw far above the deconfinement transition, we have been extending this work to β values close to the transition where the approach to chiral symmetry is much slower. We can already see that the utility of domain-wall quarks is much less obvious at these lower temperatures where the zero modes of the Dirac operator are no longer clearly separated from the non-zero modes, but much more work needs to be done.

(D. K. Sinclair)

II.A.7 A Fully Differential NLO Calculation of Single-Top-Quark Production

Brian Harris and Zack Sullivan of Argonne National Laboratory are working in collaboration with Eric Laenen and Stefan Weinzierl of NIKHEF on a fully differential next-to-leading order (NLO) calculation of the single-top-quark production cross section.

Single-top-quark production will be measured at Run II of the Fermilab Tevatron and at the CERN Large Hadron Collider (LHC), and will provide a direct measurement of the Cabibbo-Kobayashi-Maskawa (CKM) matrix element V_{tb} . The dominant uncertainty in extracting V_{tb} from the measured cross section arises from the leading order theoretical estimate of the experimental acceptance for the single b -tagged sample. Thus, it is imperative that a fully differential NLO cross section be utilized in an analysis of the data.

Several technical challenges, of relevance to generic studies involving masses and QCD, are being solved. Some of these include: Implementing a differential factorization scheme consistent with dimensional regularization in the presence of masses and anomalies; matching of the resummed calculation to the NLO particle distributions in differential phase space; and finding analytic solutions to several previously unsolved massive integrals.

(Z. Sullivan)

II.A.8 The Triangle Anomaly in Triple-Regge Limits

Regge limits are described within QCD by gauge invariant reggeon diagrams that involve reggeized gluon (or quark) propagators, reggeon interaction vertices, and external couplings to the scattering states. In an expanded version of ANL-HEP-PR-99-102 (hep-ph/9910458), Alan White has demonstrated that in massless QCD, certain reggeized gluon interactions contain an infrared divergence that can be understood as the infrared appearance of the U(1) quark anomaly. This is a new manifestation of the anomaly in a dynamical role that is

expected to be crucial for obtaining a unitary pomeron, together with confinement and chiral symmetry breaking, in (multi-)regge limits.

White shows that the triangle anomaly is present in the six-reggeon triple-regge interaction vertex obtained from a maximally non-planar Feynman diagram containing a quark loop. An asymptotic dispersion relation formalism is also used to show that in lowest-order the anomaly occurs only in such diagrams and in those related to them by reggeon Ward identities. Within a Feynman diagram, the anomaly appears because an unphysical, singular configuration approaches the asymptotic region in which every propagator in a quark loop is on-shell and one propagator carries the zero momentum necessary for a chirality transition. Within the dispersion relation formalism, the anomaly appears via the contribution of unphysical, multiple discontinuities containing the necessary chirality transition.

Even though the anomaly is present in a reggeon interaction, the structure of external couplings and/or additional symmetries of full reggeon diagrams can produce a cancellation in amplitudes. In particular, when the scattering states are elementary quarks or gluons, the anomaly always cancels. In general, such cancellations are expected to extend to any process where the chirality violation involved cannot be linked to (reggeized) gluon configurations with the quantum numbers of the winding-number current.

In a previous paper [Phys. Rev. **D58**, 074008 (1998)], White illustrated how, in a color superconducting phase with the gauge symmetry broken from $SU(3)$ to $SU(2)$, a “reggeon condensate” with the quantum numbers of the winding-number current can be consistently reproduced in all reggeon states by the anomaly infrared divergence while also producing confinement, chiral symmetry breaking, and a regge pole pomeron. $SU(3)$ gauge invariance is associated with critical pomeron behavior in which the condensate and superconductivity simultaneously disappear. Having determined the full structure of the anomaly, White plans to study this behavior in detail in future papers.

(A. R. White)

II.A.9 Geometrical Evaluation of Star Products

In recent joint work [Prog. Theo. Phys. Suppl. **135**, 244-258 (1999)], T. Curtright (U. Miami) and C. Zachos have refined and elucidated the reformulation of (scalar) quantum field theory they had introduced. It is based on quantization in infinite-dimensional field phase space, with reliance on Wigner Functions, which compose with each other through the *star-product*: the unique associative pseudodifferential deformation of ordinary products. In consequence, all field-theoretic and quantum-mechanical manipulations reduce to technical evaluations of star-products. This product was introduced in the ‘40s, but has come to underlie

cutting-edge applications of matrix models and non-commutative geometry constructions in M-physics.

In practice, however, explicit evaluations of long strings of star-products (involving chains of exponentials of derivative operators) usually appear intractable. C. Zachos [hep-th/9912238, ANL-HEP-PR-99-132] utilizes a geometric picture of the star-product based on its kernel's Fourier representation to evaluate chains of star-products efficiently. The geometrical construction proposed exhibits conspicuously the symmetries and the associativity of the star-products, both being crucial elements in investigating variant products which appear in the literature with some regularity. For instance, the geometric construction introduced leads to ready evaluation of a variant (the “Voros product”) into a spin chain. Moreover, this construction carries through for the standard star-product supersymmetrization introduced by D. Fairlie and C. Zachos in the past. Application of the method to specific problems is currently underway.

(C. Zachos)

III. ACCELERATOR RESEARCH AND DEVELOPMENT

III.A. ARGONNE WAKEFIELD ACCELERATOR PROGRAM

III.A.1 Facility Status/Upgrade Plans

X-Band Structure. We have completed the construction of the 11.4 GHz (X-band) travelling wave acceleration structure. We used as dielectric material MCT (magnesium calcium and titanium) with dielectric constant of 20. The structure has similar RF properties to the NLC X-band accelerator. This device has gone through rigorous testing, including low level RF, vacuum and high temperature. We have achieved reasonable RF transmission ($> 70\%$) and low reflection ($< 4\%$). A paper on the design and testing of this structure is forthcoming in *Reviews of Scientific Instruments*. This device will be tested at high RF power levels (> 50 MW) at SLAC using NLC rf. We expect to obtain in excess of 40 MV/m gradients during this initial test. The high power test experiment is expected to be conducted during next few months depending on the schedule at SLAC.

Step-Up Transformer Experiment Update. Both stage I and stage II tubes have been constructed and brazed. We are in the process of fixing a number of small vacuum leaks. The low energy beam line for parallel drive-witness beam operation is under construction. The spectrometer is installed and being calibrated. We will commission the new low energy line in early spring 2000.

High Current RF Gun Construction. The newly designed 1-1/2 cell RF photocathode gun is under construction. The first phase vacuum brazing has been successfully completed. The gun is currently being tuned and fine machined. We expect to have this gun ready for testing soon. We have extended the RF pulse from 4 μ s to 6 μ s for the new gun. Some minor modifications to the low-level RF and timing electronics remain to be done.

Coherent Cherenkov/Transition Radiation Experiment. We performed an experiment to study coherent radio frequency transition and Cherenkov radiation in collaboration with groups from JPL, UCLA, KU, Bartol and NIU. As well as being scientifically interesting in its own right the understanding of coherent radiation in dielectric media is of great interest as a technique for detecting high energy cosmic ray showers in natural dielectric media like the atmosphere, the lunar regolith, and the Antarctic icecap. The AWA beam intensity corresponds approximately to the peak charge excess expected in these high energy cosmic ray showers. Two pickup antennas, a 2 GHz horn and a 500 MHz bicone were used to detect coherent transition radiation from the beam exiting an aluminum beam-pipe window and coherent Cherenkov/bremsstrahlung from a SiO₂ target. Measurements of the angular dependence, beam intensity dependence, and polarization of the radiation were performed. Scaling with the square of the beam intensity verified that coherent radiation was

being detected. A paper is currently in preparation describing these results which represent the first measurements of CTR/CCR in the radio regime.

Research Direction Update. We are planning to use wakefield technology developed at ANL to generate 100 MeV electron beams. The scheme uses a step-up transformer structure and a pulse train from the new AWA RF gun as the drive beam. A detailed work plan was developed and can be found in WF-192.

(P.V. Schoessow)

III.B. MUON COLLIDER R&D

III.B.1 MUON COOLING EXPERIMENT

a. X-Rays in Muon Cooling Diagnostics

The Muon Cooling experiment, (MUCOOL), as presently designed is based on the use of low pressure time projection chambers, TPC's, to measure the position of individual muon orbits in the cooling line. Since rf cavities are known to produce large fluxes of x-rays, we have been studying the interactions of the x-rays from rf chambers with the TPC's. The low energy end of the photon spectrum seemed to be the most dangerous since the photon fluxes from a bremsstrahlung spectrum diverge faster than $1/E$ at low photon energies. Measurements of the x-ray flux seemed highly desirable and straightforward so these were done.

Working with Al Moretti and Milorad Popovic of Fermilab, we bought and installed a 300 micron Be window on a spare electron gun in the Argonne AWA enclosure, reconditioned the vacuum system, built two x-ray detectors, two sweeping magnets and shielding and connected the cavity to the rf source. Initial data, taken with different materials used as filters to isolate the different energies, shows good results. First, we have shown that the method, which, though simple, gives a useful measurement of the radiation spectrum over a wide range of intensities and photon energies. We have measured the x-ray spectrum from the cavity at two electric field levels and two angles, correlating both the spectrum and the gross radiation level in the enclosure (normalized with a Fermilab meter and Fermilab methods) with Fowler-Nordheim electron field emission. An EGS4 simulation of low angle, low energy bremsstrahlung is underway, and has produced theoretical estimates of the production x ray spectra. We have compared these predictions and data with similar cavity radiation data obtained during the tune up of the 800 MHz linac at Fermilab and the LEP cavities at CERN, and have done a preliminary statistical analysis of the data, which uses thermoluminescent detectors over 5 orders of magnitude in radiation dose. An unexpected complicating factor has been that we have had to measure, understand and suppress (!!) radiation fluxes which varied by seven orders of magnitude, depending on shielding and sweeping. This flux variation, which seems primarily due to dark current electrons which scatter easily, originally caused crosstalk in our detectors.

While interesting, this data is, at present, inconclusive, since the lowest energy photons, which are somewhat difficult to untangle from backgrounds ($\sim 10^6$ larger), are roughly in the flux range where the tracking chambers might be made to run. The critical measurement set is a more careful measurement in the forward direction of the bottom end of the photon spectrum, ($E \sim 10 - 100$ keV), and a correlation of this spectrum with gross measurements of the radiation level measured in the standard way, by setting up a meter next to the cavity.

(J. Norem)

V. PUBLICATIONS

V.A. JOURNAL PUBLICATIONS, CONFERENCE PROCEEDINGS

A Closed Formula for the Riemann Normal Coordinate Expansion

U. Müller, C. Schubert, and A.E.M. Van de Ven

J. General Relativity and Gravitation, **31:11**, 1759-1768 (1999)

Angular Dependence of the pp Elastic Scattering Analyzing Power Between 0.8 and 2.8 GeV. :

I. Results for 1.80-2.24 GeV

C.E. Allgower, M.E. Beddo, D.P. Grosnick, T.E. Kasprzyk, D. Lopiano, and
H.M. Spinka (ANL), *et al.*

Phys. Rev. **C60**, 054001 (1999)

Angular Dependence of the pp Elastic Scattering Analyzing Power Between 0.8 and 2.8 GeV: II.
Results for Higher Energies

C.E. Allgower, M.E. Beddo, D.P. Grosnick, T.E. Kasprzyk, D. Lopiano, and
H.M. Spinka (ANL), *et al.*

Phys. Rev. **C60**, 054002 (1999)

An Optimized Slab-Symmetric Dielectric-Based Laser Accelerator Structure

J.B. Rosenzweig (UCLA) and P.V. Schoessow (ANL)

Advanced Accelerator Concepts 8th Workshop, AIP Conference Proceedings 472,
edited by Wes Lawson, Carol Bellamy, and Dorothea F. Brosius (AIP, Woodbury,
NY, 1999) p. 693-700.

Associated Production of Gauginos and Gluinos at Hadron Colliders in
Next-to-Leading Order SUSY-QCD

E.L. Berger, M. Klasen, and T. Tait

Phys. Letts. **B459**, 165 (1999)

Atmospheric Neutrinos In Soudan-2

M.C. Goodman, for the Soudan 2 Collaboration

Proceedings of the 26th International Cosmic Ray Conference (ICRC 99)

"Salt Lake City 1999, Cosmic Ray," Vol. 2, (1999) p. 151-154.

PDK-734

Cosmic Ray Sun Shadow In Soudan-2 Underground Muon Flux

The Soudan 2 Collaboration, W.W.M. Allison, *et al.*

Proceedings of the 26th International Cosmic Ray Conference (ICRC 99)

"Salt Lake City 1999, Cosmic Ray," Vol. 2, (1999) p. 226-229.

PDK-731

Cygnus X-3 Revisited: 10 Years Of Muon And Radio Observations

The Soudan 2 Collaboration, W.W.M. Allison, *et al.*

Proceedings of the 26th International Cosmic Ray Conference (ICRC 990

"Salt Lake City 1999, Cosmic Ray," Vol. 2, (1999) p. 1-4.

PDK-732

Detailed Comparison of Next-to-Leading Order Predictions for Jet Photoproduction at HERA

B.W. Harris, M. Klasen, and J. Vossebeld

Proceedings of the Workshop 1998-1999 Monte Carlo Generators for HERA Physics,

edited by A. T. Doyle, G. Grindhammer, G. Ingelman, and H. Jung (DESY,

Hamburg, 1999) p. 171-180.

Elastic and Quasi-Elastic pp Scattering in ${}^6\text{LiH}$ and ${}^6\text{LiD}$ Targets Between 1.1 and 2.4 GeV

C.E. Allgower, M. Beddo, D. Grosnick, T.E. Kasprzyk, D. Lopiano, and

H.M. Spinka (ANL), J. Ball, *et al.*

Eur. Phys. J. **C11**, 51 (1999)

Four-Point Correlation Functions in the AdS/CFT Correspondence

G. Chalmers and K. Schalm

Proceedings of Trends in Mathematical Physics Conference, edited by V. Alexiades

and G. Siopsis (International Press, Knoxville, 1999) p. 121-136.

Heavy Quark Production in Deep-Inelastic Scattering at HERA

B.W. Harris, E. Laenen, S. Moch, and J. Smith

In: *Proceedings of the Workshop 1998-1999 Monte Carlo Generators for HERA*

Physics, edited by A. T. Doyle, G. Grindhammer, G. Ingelman, and H. Jung (DESY,

Hamburg, 1999) pp. 464-473.

Kinematics of $t\bar{t}$ Events at CDF

The CDF Collaboration, F. Abe, *et al.*

Phys. Rev. **D59**, 092001 (1999)

Large Analyzing Power in Inclusive π^\pm Production at High x_F with a 22-GeV/c Polarized Proton Beam

K. Krueger, C. Allgower, T. Kasprzyk, H. Spinka, D. Underwood, and

A. Yokosawa (ANL) K. Krueger, *et al.*

Phys. Lett. **B459**, 412 (1999)

Measurement of $B^0 - \bar{B}^0$ Flavor Oscillations Using Jet-Charge and Lepton Flavor Tagging in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*

Phys. Rev **D60**, 072003 (1999)

Measurement of $b\bar{b}$ Rapidity Correlations in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*

Phys. Rev. **D61**, 032001 (1999)

Measurement of b Quark Fragmentation Fractions in the Production of Strange and Light B Mesons in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*
Phys. Rev. **D60**, 092005 (1999)

Measurement of Dijet Photoproduction at High Transverse Energies at HERA

ZEUS Collaboration, J. Breitweg, *et al.*
Eur. Phys. J., **C11**, 35 (1999)

Measurement of Multiplicity and Momentum Spectra in the Current and Target Regions of the Breit Frame in Deep Inelastic Scattering at HERA

ZEUS Collaboration, J. Breitweg, *et al.*
Eur. Phys. J., **C11**, 251 (1999)

Measurement of the Associated $\gamma + \mu^\pm$ Production Cross Section in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*
Phys. Rev. **D60**, 092003 (1999)

Measurement of the $B_d^0 \bar{B}_d^0$ Oscillation Frequency Using Dimuon Data in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*
Phys. Rev. **D60**, 051101 (1999)

Measurement of the $B^0 \bar{B}^0$ Oscillation Frequency Using $\ell^- D^{*+}$ Pairs and Lepton Flavor Tags

The CDF Collaboration, T. Affolder, *et al.*
Phys. Rev. **D60**, 11204 (1999)

Measurement of the pp Analyzing Power in the Vicinity of 2.20 GeV

M. Beddo, D. Grosnick, D. Lopiano, and H.M. Spinka
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Paul Schoessow and Wei Gai

Proceedings of the 15th Advanced ICFA Beam Dynamics Workshop, "Quantum Aspects of Beam Physics," edited by P. Chen (World Scientific 1999) p. 289-299.

MSSM Higgs Boson Phenomenology at the Tevatron Collider

M. Carena, S. Mrenna, and C.E.M. Wagner
Phys. Rev. **D60**, 075010 (1999)

Neutrino Induced Muons in Soudan 2

D.M. DeMuth, for The Soudan 2 Collaboration

Proceedings of the 26th International Cosmic Ray Conference (ICRC 99)

"Salt Lake City 1999, Cosmic Ray," Vol. 2, (1999) p. 206-208.

PDK-728

Nucleon Decay In Soudan-2

M.C. Goodman, for The Soudan 2 Collaboration

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PDK-727

Observation of The Moon Shadow In Deep Underground Muon Flux

The Soudan 2 Collaboration, J.H. Cobb, *et al.*

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"Salt Lake City 1999, Cosmic Ray," Vol. 2, (1999) p. 230-233.

PDK-729

Phase-Space Quantization of Field Theory

C. Zachos and T. Curtright

Prog. Theor. Phys. Suppl. **135**:244-258 (1999)

Quantization and Scattering in the IIB SL(2, Z) Covariant Superstring

G. Chalmers and K. Schalm

JHEP 9910:016 (1999)

Quasi-Elastic pn Scattering in ${}^6\text{LiD}$ and ${}^6\text{LiH}$ Targets from 1.1 to 2.4 GeV

C.E. Allgower, M. Beddo, D. Grosnick, D. Lopiano, H.M. Spinka (ANL); A. de Lesquen, *et al.*

Eur. Phys. J. **C11**, 69 (1999)

Quantum Mechanics of Neutrino Oscillations – Hand Waving for Pedestrians

H.J. Lipkin

Proceedings of the Europhysics Neutrino Oscillation Workshop (NOW'98),

Amsterdam, The Netherlands, 7-9 September 1998,

<http://www.nikhef.nl/pub/conferences/now98/>.

Renormalon Ambiguities in NRQCD Operator Matrix Elements

G.T. Bodwin and Y.-Q. Chen

Phys. Rev. **D60**, 054008 (1999)

Search for a Technicolor ω_T Particle in Events with a Photon and a b -Quark Jet at Fermilab

The CDF Collaboration, F. Abe, *et al.*

Phys. Rev. Lett. **83**, 2133 (1999)

Search for $B_s^0 - \bar{B}_s^0$ Oscillations Using the Semileptonic Decay $B_s^0 \rightarrow \phi \ell^+ X \nu$

The CDF Collaboration, F. Abe, *et al.*

Phys. Rev. Lett. **82** (18) 3576 (1999)

Search for Neutrinos from Active Galactic Nuclei in Soudan 2

D.M. DeMuth, for The Soudan 2 Collaboration

Proceedings of the 26th International Cosmic Ray Conference (ICRC 99)

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PDK-726

Search for New Particles Decaying to $b\bar{b}$ in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*

Phys. Rev. Lett. **82**, 2038 (1999)

Search for R -Parity Violating Supersymmetry Using Like-Sign Dielectrons in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*

Phys. Rev. Lett. **83**, 2133 (1999)

Search for the Flavor-Changing Neutral Current Decays $B^+ \rightarrow \mu^+ \mu^- K^+$ and $B^0 \rightarrow \mu^+ \mu^- K^{*0M}$

The CDF Collaboration, T. Affolder, *et al.*

Phys. Rev. Lett. **83**, 3378 (1999)

Search for Third-Generation Leptoquarks from Technicolor Models in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*

Phys. Rev. Lett. **82**, 3206 (1999)

Searches for New Particles Decaying to $b\bar{b}$ in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*

Phys. Rev. Lett. **82**, 2038 (1999)

Searches for New Physics in Diphoton Events in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*

Phys. Rev. **D59**, 092002 (1999)

Seasonal Variations In Soudan-2

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PDK-733

Single Top Squark Production Via R Parity Violating Supersymmetric Couplings in Hadron Collisions

E.L. Berger, B.W. Harris, and Z. Sullivan
Phys. Rev. Lett. **83**:4472-4475 (1999)

SRRC/ANL High Current L-Band Single Cell Photocathode RF Gun

C.H. Ho, T.T. Yang, J.Y. Hwang, G.Y. Hsiung, S.Y. Ho, M.C. Lin (Taiwan, Synchrotron Radiation Res. Ctr.), M. Conde, W. Gai, R. Konecny, J. Power, and P. Schoessow (ANL)
Proceedings of the 6th European Particle Accelerator Conference (EPAC98),
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Status of Muon Collider Research and Development and Future Plans

Charles M. Ankenbrandt, *et al.* (Muon Collider Collaboration)
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The Large- N_c Limit of Four-Point Functions in $N=4$ Super Yang-Mills Theory via Anti-de Sitter Supergravity

G. Chalmers and K. Schalm
Nucl. Phys. **B554**:215-236 (1999)

The Production of Charginos/Neutralinos and Stopped at Hadron Colliders

W. Beenakker and M. Klasen, *et al.*
Phys. Rev. Lett. **83**, 3780-3783 (1999)

Wakefield Excitation in Multimode Structures by a Train of Electron Bunches (Revised.)

J. G. Power, Wei Gai, and P. Schoessow
Phys. Rev. **E60** (5) 6061 (1999)

V.B. PAPERS SUBMITTED FOR PUBLICATION

Angular and Current-Target Correlations in Deep Inelastic Scattering at HERA

ZEUS Collaboration, J. Breitweg, *et al.*
Eur. Phys. J.
ANL-HEP-PR-99-85

Construction and Testing of an 11.4 GHz Dielectric Structure Based Travelling Wave Accelerator

P. Zou, W. Gai, R. Konecny, X. Sun, T. Wong, and A. Kanareykin
Accepted for publication in Reviews of Scientific Instruments
ANL-HEP-PR-99-117

Cosmological Magnetic Fields From Gauge Mediated Supersymmetry Breaking Models

A. Kandus, E.A. Calzetta, F. D. Mazzitelli, and C.E.M. Wagner
Phys. Lett. B
ANL-HEP-PR-99-86

Current-Target Correlations as a Probe of $\Delta G/G$ in Polarized Deep Inelastic Scattering
S. Chakanau

Accepted for publication in Physics Letters B
ANL-HEP-PR-99-89

Effective Lagrangian for the $\bar{t}bH^+$ Interaction in the MSSM and Charged Higgs Phenomenology

M. Carena, D. Garcia, U. Nierste, and C.E.M. Wagner
Nucl. Phys. B
ANL-HEP-PR-00-063

Electrons in the VLHC Tunnels: the e^+e^- and ep Options

J. Norem (ANL) and T. Sen (FNAL)
Nucl. Inst. and Meth.
ANL-HEP-PR-99-103

Geometrical Evaluation of Star Products

C. Zachos
J. Math. Phys.
ANL-HEP-PR-99-132

Large x Parton Distributions

S. Kuhlmann, *et al.*
Phys. Lett.
ANL-HEP-PR-99-126

Measurement of $b\bar{b}$ Rapidity Correlations in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, F. Abe, *et al.*
Phys. Rev. D
ANL-HEP-PR-00-41

Measurement of b -Quark Fragmentation Fractions in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, T. Affolder, *et al.*
Phys. Rev. Lett.
ANL-HEP-PR-00-36

Measurement of $D^{*\pm}$ Production and the Charm Contribution to F_2 in Deep Inelastic Scattering at HERA

ZEUS Collaboration, J. Breitweg, *et al.*
Eur. Phys. J. C
ANL-HEP-PR-99-94

Measurement of Diffractive Photoproduction of Vector Mesons at Large Momentum Transfer at HERA (Oct. 1999)

J. Breitweg, S. Chekanov, M. Derrick, D. Krakauer, S. Magill, B. Musgrave,
A. Pellegrino, J. Repond, R. Stanek, and R. Yoshida
Eur. Phys. J. C
ANL-HEP-PR-99-119

Measurement of High- Q^2 Neutral-Current e+p Deep Inelastic Scattering Cross-Sections at HERA

J. Breitweg, S. Chekanov, M. Derrick, D. Krakauer, S. Magill, B. Musgrave,
A. Pellegrino, J. Repond, R. Stanek, and R. Yoshida
Eur. Phys. J. C
ANL-HEP-PR-99-81

Measurement of Inclusive $D^{*\pm}$ and Associated Dijet Cross Sections in Photoproduction at HERA

ZEUS Collaboration, J. Breitweg, *et al.*
Eur. Phys. J.
ANL-HEP-PR-99-68

Measurement of Inclusive Prompt Photon Photoproduction at HERA (Oct. 1999)

J. Breitweg, S. Chekanov, M. Derrick, D. Krakauer, S. Magill, B. Musgrave,
A. Pellegrino, J. Repond, R. Stanek, and R. Yoshida
Accepted for publication in the European Journal of Physics C
ANL-HEP-PR-99-122

Measurement of $\sin 2\beta$ from $B \rightarrow J/\psi K_s^0$ with the CDF Detector

The CDF Collaboration, F. Abe, *et al.*
Phys. Rev. D
ANL-HEP-PR-00-72

Measurement of the E_T^2 , Jet/ Q^2 Dependence of Forward-Jet Production at HERA

ZEUS Collaboration, J. Breitweg, *et al.*
Phys. Lett. B
ANL-HEP-PR-99-121

Measurement of the Helicity of W Bosons in Top Quark Decays

The CDF Collaboration, T. Affolder, *et al.*
Phys. Rev. Lett.
ANL-HEP-PR-00-40

Measurement of the Spin-Density Matrix Elements in Exclusive Electroproduction of ρ^0 Mesons at HERA

ZEUS Collaboration, J. Breitweg, *et al.*
The European Physical Journal C
ANL-HEP-PR-99-93

Measurements of Wakefields in a Multimode, Dielectric Wakefield Accelerator Driven by a Train of Electron Bunches

J.G. Power, M.E. Conde, W. Gai, R. Konecny, Paul Schoessow (ANL)
and A.D. Kanareykin

Phys. Rev. Special Topics: Accelerators and Beams
ANL-HEP-PR-00-35

Neutrino Oscillations as Two-Slit Experiments in Momentum Space

H.J. Lipkin

Phys. Letts.
ANL-HEP-PR-99-70

New Topflavor Models with Seesaw Mechanism

H.-J. He, T. Tait, and C.-P. Yuan

Phys. Rev. Lett.
ANL-HEP-PR-99-115

NLO QCD Predictions for Internal Jet Shapes in DIS at HERA

J. Repond

Phys. Lett. B
ANL-HEP-PR-99-53

Observation of Diffractive b -Quark Production at the Fermilab Tevatron

The CDF Collaboration, T. Affolder, *et al.*

Phys. Rev. Lett.
ANL-HEP-PR-00-39

Observation Of Plasma Wakefield Acceleration In The Underdense Regime

N. Barov, J.B. Rosenzweig, M.E. Conde, W. Gai, and J.G. Power

Phys. Rev. ST: Accelerator and Beams
ANL-HEP-PR-00-12

Production of $\Upsilon(1S)$ Mesons from χb Decays in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, T. Affolder, *et al.*

Phys. Rev. Lett.
ANL-HEP-PR-00-53

Quantization and Scattering in the IIB $SL(2, Z)$ Covariant Superstring

G. Chalmers and K. Schalm

JHEP
ANL-HEP-PR-99-78

Reconciling the Two-Loop Diagrammatic and Effective Field Theory Computations of the Mass of the Lightest CP-Even Higgs-Boson in the MSSM

C.E.M. Wagner, *et al.*

Nucl. Phys. B
ANL-HEP-PR-99-109

Search for a Fourth-Generation Quark More Massive than the Z^0 Boson in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, T. Affolder, *et al.*

Phys. Rev. Lett

ANL-HEP-PR-00-38

Search for Color Singlet Technicolor Particles in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

The CDF Collaboration, T. Affolder, *et al.*

Phys. Rev. Lett.

ANL-HEP-PR-00-37

Search for Contact Interactions in Deep Inelastic $e^+p \rightarrow e^+X$ Scattering at HERA

ZEUS Collaboration, J. Breitweg, *et al.*

Eur. J. Phys. C

ANL-HEP-PR-99-83

Search for Nucleon Decay into Lepton + K^0 Final States Using Soudan 2

The Soudan 2 Collaboration, D. Wall, *et al.*

Phys. Rev. D

ANL-HEP-PR-99-123

PDK-743

Search for Nucleon Decay with Final States $\ell^+\eta^0$, $\bar{\nu}\eta^0$, and $\bar{\nu}\pi^{+,0}$ Using Soudan 2

The Soudan 2 Collaboration, D. Wall, *et al.*

Phys. Rev. D

ANL-HEP-PR-99-124

PDK-744

Spin Dependence of Massive Lepton Pair Production in Proton-Proton Collisions

E.L. Berger, L.E. Gordon, and M. Klasen

Phys. Rev. D

ANL-HEP-PR-99-97

Supersymmetry Breaking Through Transparent Extra Dimensions

D.E. Kaplan, G.D. Kribs, and M. Schmaltz

Phys. Rev. D

ANL-HEP-PR-99-110

Tevatron Direct Photon Results

S. Kuhlmann

Nucl. Phys.

ANL-HEP-PR-99-96

The Complementarity of LEP, the Tevatron and LHC in the Search for a Light MSSM Higgs Boson

M. Carena, S. Mrenna, and C.E.M. Wagner
Phys. Rev. D
ANL-HEP-PR-99-79

The Intermediate Coupling Regime in the AdS/CFT Correspondence

G. Chalmers
Phys. Lett. B
ANL-HEP-PR-99-77

The Observation of a Shadow of the Moon in the Underground Muon Flux in the Soudan 2 Detector

D.S. Ayres, T.H. Fields, M.C. Goodman, T. Joffe-Minor, W. Leeson, L.E. Price,
J.L. Thron (ANL), and the Soudan 2 Collaboration
Phys. Rev. D
ANL-HEP-PR-99-59

The Transverse Momentum and Total Cross Section of e^+e^- Pairs in the Z-Boson Region from $p\bar{p}$ Collisions at $\sqrt{s}=1.8$ TeV

The CDF Collaboration, T. Affolder, *et al.*
Phys. Rev. Lett.
ANL-HEP-PR-00-42

The Triangle Anomaly in Triple-Regge Limits

A.R. White
Phys. Rev.
ANL-HEP-PR-99-102

The Triple-Regge Triangle Anomaly

A.R. White
Phys. Rev. Letts
ANL-HEP-PR-99-108

The tW^- Mode of Single Top Production

T. Tait
Phys. Rev. D
ANL-HEP-PR-99-98

W Production and the Search for Events with an Isolated High-Energy Lepton and Missing Transverse Momentum at HERA

ZEUS Collaboration, J. Breitweg, *et al.*
Phys. Lett. B
ANL-HEP-PR-00-25

V.C. PAPERS OR ABSTRACTS CONTRIBUTED TO CONFERENCES

A High-Charge High-Brightness L-Band Photocathode RF Gun

M.E. Conde, W. Gai, R. Konecny, J.G. Power, P. Schoessow, and X. Sun
Accepted for publication in the proceedings of The 2nd ICFA Beam
Dynamics Workshop on The Physics of High Brightness Beams,
Los Angeles, CA, November 9-11, 1999.
ANL-HEP-CP-00-07

A Prototype ROI Builder for the Second Level Trigger of ATLAS Implemented in FPGA's

R.E. Blair, J.W. Dawson, W.N. Haberichter, and J. Schlereth
Proceedings, Fifth Workshop on Electronics for LHC Experiments,
University of Wisconsin, Madison, WI (September 20-24, 1999).
ANL-HEP-CP-99-118

Calorimetry Using Organic Scintillators, A Sideways Perspective.

J. Proudfoot
VIII International Conference on Calorimetry in High Energy Physics, Lisbon
Portugal, June 13-19, 1999.
ANL-HEP-CP-99-92

High Temperature Meson Propagators with Domain-Wall Quarks.

J.-F. Lagaë and D.K. Sinclair
XVII International Symposium on Lattice Field Theory (LATTICE'99), Pisa, Italy,
June 28 – July 3, 1999.
ANL-HEP-CP-99-91

Issues in Leading Particle and Charm Production in DIS

S. Chakanau
Accepted for publication in the proceedings of the Monte Carlo Generators
Workshop for HERA Physics, DESY Laboratory, Hamburg, Germany, June 1999.
ANL-HEP-CP-99-88

J/ψ Production: Tevatron and Fixed-Target Collisions

A. Petrelli
HEP International Euroconference on Quantum Chromodynamics (QCD'99),
Montpellier, France, July 7-13, 1999.
ANL-HEP-CP-99-107

Open Charm Production in Deep Inelastic Scattering at Next-to-Leading Order at HERA

B.W. Harris
Ringberg Workshop on New Trends in HERA Physics, Rottach-Egern, Germany,
May 30 – June 4, 1999.
ANL-HEP-CP-99-69

Photon Structure and the Production of Jets, Hadrons, and Prompt Photons

M. Klasen

Ringberg Workshop on New Trends in HERA Physics, Rottach-Egern, Germany,
May 30 – June 4, 1999.

ANL-HEP-CP-99-73

Recent Atmospheric Neutrino Results from Soudan 2

T. Kafka for the Soudan 2 Collaboration (M. Goodman, *et al.*)

Proceedings of TAUP'99, College de France, September 6-10, 1999.

ANL-HEP-CP-99-125

PDK 742

Report of SUGRA Working Group for Run II of the Tevatron

C.E.M. Wagner, E. Berger, B.W. Harris, M. Klasen, Z. Sullivan, T. Tait, *et al.*

Proceedings of the Workshop on Physics at Run II -- Supersymmetry/Higgs,
Batavia, IL, November 19-21, 1999.

ANL-HEP-CP-99-101

Short-Range and Long-Range Correlations in DIS at HERA

S.V. Chekanov and L. Zawiejski

Proceedings of the XXIX International Symposium on Multiparticle Dynamics,
Brown University, Providence, RH, August 9-13, 1999.

ANL-HEP-CP-99-99

Summary of Experimental Talks

M. Derrick

Proceedings of the XXIX International Symposium on Multiparticle Dynamics,
Brown University, Providence, RH, August 9-13, 1999.

ANL-HEP-CP-99-120

The Operation of the BNL/ATF Gun-IV Photocathode RF Gun at the Advanced Photon Source

S.G. Biedron, G.A. Goepfner, J.W. Lewellen, S.V. Milton, J.G. Power, *et al.*

Proceedings of the 1999 IEEE Particle Accelerator Conference, New
York, NY, March 27 - April 2, 1999.

ANL-HEP-CP-00-34

Theoretical Summary of the Conference

H.J. Lipkin

Eighth International Conference on Hadron Spectroscopy (Hadron'99), Beijing,
China, August 24-28, 1999.

ANL-HEP-CP-99-116

The Triangle Anomaly in Triple-Regge Limits

A.R. White

XXIXth International Symposium on Multiparticle Dynamics (ISMD'99), Brown
University, Providence, RI, August 9-13, 1999.

ANL-HEP-CP-99-112

V.D. TECHNICAL REPORTS AND NOTES

Antiprotons and the Crystal Ball

Chris Allgower and David Peaslee
ANL-HEP-TR-99-114

Continued Study of the Time Stability of a Small Water Cerenkov Detector

D. Strom, H. Glass, H. Spinka, and M. Thomure
ANL-HEP-TR-00-24

Purified Water Quality Study

H. Spinka, P. Jackowski
ANL-HEP-TR-00-16

NuMI Notes:

NuMI-L-544

Four Plane Prototype Module Production at Argonne, October 11, 1999.
Tacy Joffe-Minor, *et al.*

NuMI-E-548

Physics Justification for a Hybrid Emulsion Detector in MINOS, October 1999.
The MINOS Collaboration

NuMI-E-549

MINOS Far Detector Lab Design Criteria Document for the Cavern and Detector
Outfitting, Version 2.6, December 1999.
D. Ayres, A. Byon-Wagner, J. Kilmer, W. Miller, E. Peterson, R. Plunkett,
D. Pushka, and R. Trendler

PDK Notes:

PDK-742

Recent Atmospheric Neutrino Results from Soudan 2
T. Kafka, for the Soudan 2 Collaboration
Presented at TAUP'99, College de France, September 6-10, 1999.
ANL-HEP-CP-99-125

PDK-743

Search for Nucleon Decay into Lepton + K^0 Final States Using Soudan 2
D. Wall, *et al.* (the Soudan 2 Collaboration)
Submitted to Phys. Rev. D
ANL-HEP-PR-99-123

PDK-744

Search for Nucleon Decay with Final States $\ell^+\eta^0$, $\bar{\nu}\eta^0$, and $\bar{\nu}\pi^{+,0}$ Using Soudan 2

D. Wall, *et al.* (the Soudan 2 Collaboration)

Submitted to Phys. Rev. D

ANL-HEP-PR-99-124

RHIC Spin Notes:

RHIC # 79

Note on RHIC Polarimetry

H. Spinka

July 12, 1999

STAR Notes:

STAR # 405

Note on RHIC Polarimetry

H. Spinka

July 12, 1999

Wakefield Notes:

WF-185

Dispersion Curves of the Dielectric Tube

X. Sun and P. Zou

August 24, 1999

WF-186

Calculation of PETS Using Dielectrics for CLIC Type TBA Applications

Wei Gai

September 30, 1999

WF-187

Transformer Ratio Enhancement Using a Ramped Bunch Train in a Collinear Dielectric Wakefield Accelerator

J.G. Power, W. Gai, and A. Kanareykin

October 1, 1999

WF-188

Q Calculation for Dielectric Loaded SW Cavity in TM-01p Mode

John Power

October 20, 1999

VI. COLLOQUIA AND CONFERENCE TALKS

Edmond L. Berger

"Spin Dependence of Massive Lepton Pair Production in Proton-Proton Collisions"
Circum-Pan-Pacific RIKEN Symposium on High Energy Spin Physics, Wako, Japan,
November 1-6, 1999.

Geoffrey T. Bodwin

"Renormalons and Resummation in Heavy-Quarkonium Decay Rates"
University of Illinois, Urbana, November 1, 1999.

"Inclusive Production of Heavy Quarkonium in Hadronic Collisions"
Workshop on B Physics at the Tevatron: Run II and Beyond, FNAL, Batavia, IL,
September 23-24, 1999.

Gordon Chalmers

"Relations Between $N=2$ String Amplitudes and MHV Amplitudes"
Department of Physics, UCLA, Los Angeles, CA, September 12-23, 1999.

"Four-Point Correlation Functions in the AdS/CFT Correspondence"
Workshop on String Theory, Aspen, CO, August 30-September 12, 1999.

"Progress in Amplitude Relations Between Yang-Mills Theories and $N=2$ Strings"
ANL-HEP Theory Seminar, August 23, 1999.

Maury Goodman

"MINOS"
NNN99 - Invited talk at the International Workshop on Next Generation
Nucleon Decay and Neutrino Detector International Workshop on Next
Generation Nucleon Decay and Neutrino Detector, The State University of
New York at Stony Brook, September 23-25, 1999.

"Atmospheric Neutrinos in Soudan 2"
ICRC - Highlight Talk at 1999 International Conference on Cosmic Ray
Physics, Salt Lake City Utah, August 17-25, 1999.

"Report from the International Cosmic Ray Conference"
ANL-HEP Lunch Seminar, September 28, 1999.

"Results from the Soudan 2 Experiment"
High Energy Physics Seminar, University of Illinois in Urbana,
October 1999.

Brian Harris

"Reach of Fermilab Tevatron Upgrades for Higgs Bosons"
Michigan State University, East Lansing, MI, November 30, 1999.

"Reach of Fermilab Tevatron Upgrades for Higgs Bosons"
Southern Methodist University, Dallas, TX, November 15, 1999.

"Charm Fragmentation Issues at Hera"
Workshop on B Physics at the Tevatron: Run II and Beyond, FNAL, Batavia, IL,
September 23-24, 1999.

David Kaplan

"Supersymmetry Breaking Through Transparent Extra Dimensions"
University of Chicago, High Energy Physics Seminar, November 22, 1999.

"Flavor Mediated Supersymmetry Breaking"
Michigan State University, East Lansing, November 9, 1999.

Tom LeCompte

"Frontiers of QCD at RHIC"
EFI, The University of Chicago, October 18, 1999.

Eve Kovacs

"LINUX for Dummies"
ANL-HEP Lunch Seminar, September 21, 1999.

Harry J. Lipkin

"Hyperons - Total Cross Sections and Spin Structure, New Data and Implications for QCD"
ANL-HEP Lunch Seminar, August 3, 1999.

Andrea Petrelli

"Results in Quarkonium Phenomenology"

HEP International Euroconference on Quantum Chromodynamics (QCD'99),
Montpellier, France, July 7-13, 1999.

Gordon P. Ramsey

"A Comparison of Spin Observable Predictions"

Circum-Pan-Pacific RIKEN Symposium on High Energy Spin Physics, Wako, Japan,
November 4, 1999.

"The Status of High Energy Spin Physics"

Illinois Institute of Technology, Chicago, October 7, 1999.

Jose Repond

"Highlights from HERA"

Electromagnetic Interactions with Nucleons and Nuclei Conference,
Santorini, Greece, October 1999.

Hal Spinka

"Nucleon-Nucleon Elastic Scattering Spin Measurements"

Ball State University, Muncie, Indiana, December 2, 1999.

"Systematics in Polarization Measurements"

Workshop on RHIC Spin, Brookhaven Lab, Upton, NY, October 8, 1999.

Zack Sullivan

"R-Parity Violation and Single Top Squarks at the Tevatron"

Indiana University, Bloomington, IN, September 20, 1999.

Timothy Tait

"The Top Quark as a Conspirator in the Electroweak Symmetry Breaking"

Physics Department, Purdue University, West Lafayette, Indiana, October 19, 1999.

"The Top Quark as a Conspirator in the Electroweak Symmetry Breaking"

Physics Department, Indiana University, Bloomington, IN, October 18, 1999.

Carlos Wagner

"Diagrammatic Computation and Leading-Log Approximation of the Higgs-Boson Mass in the MSSM"

Physics Department, University of Wisconsin, Madison, October 19, 1999.

"The Phenomenology of Theories with Large Extra Dimensions"

ANL-HEP Lunch Seminar, July 27, 1999.

Alan R. White

"The Triangle Anomaly in Triple-Regge Limits"

XXIXth International Symposium on Multiparticle Dynamics (ISMD '99), Brown University, Providence, RI, August 9-13, 1999.

VII. HIGH ENERGY PHYSICS COMMUNITY ACTIVITIES

David S. Ayres

Manager, Acting.

Deputy Spokesperson, the MINOS Collaboration.

Edmond L. Berger

Adjunct Professor of Physics, Michigan State University, East Lansing, MI, 1997-present.

Member, CTEQ Collaboration.

Member, High Energy and Nuclear Physics Advisory Committee, Brookhaven National Laboratory, 1995-2001.

Convenor, Physics at Run II Working Group on Photons and Weak Bosons, Fermilab, Batavia, IL, January - December, 1999.

Organizing Committee, Theory Institute on Supersymmetry and Higgs 2000, Argonne National Laboratory, Argonne, IL, April 25 – May 12, 2000.

Organizing Committee, Seventh Conference on the Intersections Between Particle and Nuclear Physics, May-June, 2000.

Member, International Advisory Committee, Eighth International Conference on Hadron Spectroscopy, Beijing, China, August, 1999.

International Advisory Committee, Frontiers in Science '99, Blois, France, June-July, 1999.

Scientific Program Organizing Committee, XXXVth Rencontres de Moriond, QCD and High Energy Hadronic Interactions, France, March, 2000.

Scientific Program Organizing Committee, Fourth Rencontres du Vietnam, Physics at Extreme Energies, Hanoi, July, 2000.

Scientific Advisory Committee, Frontiers in Contemporary Physics-II, Vanderbilt University, March 5-10, 2001.

Wei Gai

Member, Advanced Accelerator Workshop Scientific and Organizing Committee.

Maury C. Goodman

Member, Particle Data Group.

Secretary, MINOS executive Committee.

Member, International Advisory Committee for Neutrino 2000.

Harry J. Lipkin

Member, International Advisory Committee, Eighth International Conference on Hadron Spectroscopy, Beijing, China, August, 1999.

Edward N. May

Member, Staff of ESnet Steering Committee.

Lawrence J. Nodulman

Member, Fermilab Users Organization Executive Committee.

James Norem

Member, Muon Collider Group Technical Committee.

Lawrence E. Price

Chair, ESnet Steering Committee.

Gordon Ramsey

Member, International Advisory Committee, Circum-Pan-Pacific Workshops on High Energy Spin Physics, 1996-present.

Member, SPIN Collaboration.

Jose Repond

Member, the International Advisory Committee for the 8th International Workshop on Deep Inelastic Scattering and QCD.

Paul Schoessow

Webmaster, the APS/Division of Beam Physics.

Hal Spinka

Chairman, the Technical, Cost, and Schedule Review for the Los Alamos $n + p \rightarrow d + \gamma$ experiment.

Alan R. White

Diffractive Coordinator, XXIXth International Symposium on Multiparticle Dynamics, QCD and Multiparticle Production, Brown University, Providence, RI, August 9-13, 1999.

VIII. HEP DIVISION RESEARCH PERSONNEL

Administration

L. Price

D. Hill

Accelerator Physicists

M. Conde

W. Gai

J. Norem

J. Power

P. Schoessow

Experimental Physicists

D. Ayres

R. Blair

K. Byrum

S. Chekanov

M. Derrick

T. Fields

M. Goodman

D. Krakauer

S. Kuhlmann

T. LeCompte

T. Joffe-Minor

S. Magill

E. May

B. Musgrave

L. Nodulman

E. Peterson

J. Proudfoot

J. Repond

H. Spinka

R. Stanek

R. Talaga

J. Thron

R. Thurman-Keup

D. Underwood

R. Wagner

A. Wicklund

A. Yokosawa

R. Yoshida

Theoretical Physicists

E. Berger

G. Bodwin

G. Chalmers

B. Harris

D. Kaplan

M. Klasen

A. Petrelli

D. Sinclair

Z. Sullivan

T. Tait

C. Wagner

A. White

C. Zachos

Engineers, Computer Scientists, and Applied Scientists

J. Dawson

G. Drake

V. Guarino

W. Haberichter

N. Hill

E. Kovacs

J. Schlereth

Technical Support Staff

I. Ambats
S. Anderson
A. Caird
G. Cox
T. Cundiff
F. Franchini
D. Jankowski
T. Kasprzyk
L. Kocenko

R. Konecny
Z. Matijas
T. Nephew
L. Reed
R. Rezmer
J. Rick
F. Skrzecz
K. Wood

Laboratory Graduate Participants

J. Breitweg
W. Bell
P. Zou

Visiting Scientists

Y.-Q. Chen (Theory)
E. Kovacs (Theory)
H. Lipkin (Theory)
P. Orland (Theory)

G. Ramsey (Theory)
Xiang Sun, (AWA)
J. Uretsky (Theory)
T. Wong (AWA)